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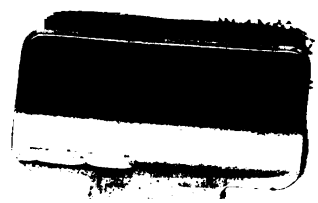

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WATER TERMINAL AND TRANSFER FACILITIES

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GENERAL PLANS OF

U.S. Board of Engineers for Rivers and Harbors.

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WATER TERMINAL AND TRANSFER FACILITIES

LETTER

FROM

THE SECRETARY OF WAR

TRANSMITTING

WITH A LETTER FROM THE CHIEF OF ENGINEERS, REPORTS OF AN INVESTIGATION OF THE GENERAL SUBJECT OF WATER TERMINALS, WITH DESCRIPTIONS AND GENERAL PLANS OF TERMINALS OF APPROPRIATE TYPES AND CONSTRUCTION FOR THE HARBORS AND WATERWAYS OF THE UNITED STATES SUITABLE FOR VARIOUS COMMERCIAL PURPOSES AND ADAPTED TO THE VARYING CONDITIONS OF TIDES, FLOODS, AND OTHER PHYSICAL CHARACTERISTICS

and Harbors

AUGUST 24, 1921.—Referred to the Committee on Rivers and Harbors and ordered to be printed, with illustrations

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67TH CONGRESS, 1st Session. } HOUSE OF REPRESENTATIVES. { DOCUMENT No. 109.

WATER TERMINAL AND TRANSFER FACILITIES.

LETTER

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AUGUST 24, 1921.—Referred to the Committee on Rivers and Harbors and ordered to be printed, with illustrations.

WAR DEPARTMENT,
Washington, July 18, 1921.

SIR: I have the honor to transmit herewith a letter from the Chief of Engineers, United States Army, of this date, submitting, pursuant to the provisions of subparagraph (d) of section 7 of the river and harbor act approved July 18, 1918, a report by the Board of Engineers for Rivers and Harbors on the general subject of water terminals.

The illustrations accompanying these reports are necessary to a complete understanding of the matter and it is recommended that all of them be printed.

Very respectfully,

JOHN W. WEEKS,
Secretary of War.

The SPEAKER OF THE HOUSE OF REPRESENTATIVES.

WAR DEPARTMENT,
OFFICE OF THE CHIEF OF ENGINEERS,
Washington, July 18, 1921.

From: The Chief of Engineers, United States Army.
To: The Secretary of War.
Subject: Water terminal and transfer facilities.

1. There is submitted herewith for transmission to Congress a report by the Board of Engineers for Rivers and Harbors in com-

pliance with subparagraph (d) of section 7 of the river and harbor act approved July 18, 1918, on an investigation of the general subject of water terminals. The report on the other sections of the law referred to has been transmitted to Congress and ordered printed as House Document No. 652, Sixty-sixth Congress, second session.

2. In view of the importance of the subject of this report and the necessity of the illustrations for a proper understanding of it, it is urgently recommended that this report be printed in its entirety, together with all illustrations.

LANSING H. BEACH,
Major General, Chief of Engineers.

REPORT OF THE BOARD OF ENGINEERS FOR RIVERS AND HARBORS.

WAR DEPARTMENT,
BOARD OF ENGINEERS FOR RIVERS AND HARBORS,
Washington, May 2, 1921.

From: The Board of Engineers for Rivers and Harbors.
To: The Chief of Engineers, United States Army.
Subject: Water terminal and transfer facilities.

1. Under date of January 20, 1920, the Acting Chief of Engineers addressed the Secretary of War on the above subject, quoting section 7 of the river and harbor act approved July 18, 1918, as follows:

That hereafter the Chief of Engineers, United States Army, shall indicate in his annual reports the character of the terminal and transfer facilities existing on every harbor or waterway under maintenance or improvement by the United States, and state whether they are considered adequate for existing commerce. He shall also submit one or more special reports on this subject as soon as possible, including, among other things, the following:

(a) A brief description of such water terminals, including location and the suitability of such terminals to the existing traffic conditions, and whether such terminals are publicly or privately owned, and the terms and conditions under which they may be subjected to public use.

(b) Whether such water terminals are connected by a belt or spur line of railroad with all the railroads serving the same territory or municipality, and whether such connecting railroad is owned by the public and the conditions upon which the same may be used, and also whether there is an interchange of traffic between the water carriers and the railroad or railroads as to such traffic which is carried partly by rail and partly by water to its destination, and also whether improved and adequate highways have been constructed connecting such water terminal with the other lines of highways.

(c) If no water terminals have been constructed by the municipality or other existing public agency, there shall be included in his report an expression of opinion in general terms, as to the necessity, number, and appropriate location of such a terminal or terminals.

(d) An investigation of the general subject of water terminals, with descriptions and general plans of terminals of appropriate types and construction for the harbors and waterways of the United States suitable for various commercial purposes and adapted to the varying conditions of tides, floods, and other physical characteristics.

2. The second paragraph of the above-mentioned letter is quoted as follows:

The necessary steps have been taken to include in the annual reports the information first mentioned in the above-quoted item of law. There are submitted herewith for transmission to Congress special reports giving for each river and harbor district the information specified under paragraphs (a), (b),

and (c), and in part the information required under paragraph (d). To complete the information called for in paragraph (d), an investigation of the general subject of water terminals is now in progress by the Board of Engineers for Rivers and Harbors, and separate report on this subject will be submitted as soon as practicable, with descriptions and general plans of terminals of appropriate types and construction for the harbors and waterways of the United States.

3. House Document No. 652, Sixty-sixth Congress, second session, on the above subject is now ready for issue, and in order to complete the requirement of section 7 an investigation has been made of the general subject of water terminals, and there is attached hereto a separate report on this subject, with descriptions and general plans of terminals of appropriate types and construction for the harbors and waterways of the United States.

4. While the accompanying report, prepared by Capt. F. T. Chambers, Civil Engineer Corps, United States Navy, thoroughly covers the subject of subparagraph (d) of section 7 of the act approved July 18, 1918, it may be pertinent to amplify it by some general views on water terminals.

5. Terminal cost is relatively great as compared to the cost of transportation proper, whether by rail or by water. Frequently the cost of terminal operations forms a very substantial fraction of the entire amount charged for lifting goods at the point of origin and delivering them at destination. That this is true may be seen from the figures given in various portions of Capt. Chambers's report. The cost of transfer, even when excellent facilities are employed, is ordinarily from 50 cents to $1 a ton, and that of trucking is $1 to $2 per ton for distances of a mile or less. In such localities as New York transfer costs may rise to $3 per ton, and trucking costs may be greater than figures already given. On the other hand, the cost of transportation by rail is for first-class freight from 3 to 5 cents per ton-mile for distances of 500 miles or more, and for bulk freight from 5 to 8 or 9 mills per ton-mile for corresponding distances. By water the charge for package freight is usually somewhat less than the rail rate, and in the case of bulk freight is often very much smaller than the rail charge, the well-known rates for carrying iron ore and coal on the Great Lakes being characteristic examples, so that it will be seen that the total terminal cost may often be enough to carry the freight many miles by rail or by water.

6. While it may be possible to introduce some relatively small additional economies in the vehicles used for long-distance transportation, whether by land or water, the limits of efficiency in this direction have been very closely approached, and if there is to be any considerable reduction to the shipper in the cost of getting his goods to their market, it must probably be largely as a result of the introduction of properly designed terminals incorporating the latest and most efficient appliances for handling traffic of the character and volume involved.

7. This report bears specifically, however, upon water transportation and upon the means that may be adopted for enhancing its economy. Water transportation may be divided into three classes:

First. Ocean transportation in our foreign trade: In this case all transfers involved are obligatory and can not be avoided, as there is no other route available for getting goods from the point of production to their market.

Second. Ocean transportation, coastwise: Here the draft of the carriers is limited usually by the depth of the smaller ports involved, but conditions indicate that transportation may, as a rule, be conducted at less cost than by rail. The coastwise route is usually no longer than the competing rail route, but it generally involves one or more extra transfers as compared with rail.

Third. Inland waterway transportation by routes whose draft is usually limited and relatively small. Due to the sinuosities of the waterways concerned, the route is generally longer than the rail route, sometimes considerably longer, and due to limitations upon the character of carriers that may be used the units employed must generally be of less capacity than those employed on the high seas. The possibility of economy in actual transportation will depend upon careful management, upon the assemblage of the barges or carriers in fleets, and upon the utilization of every device available to reduce terminal delays and charges. Usually, but not always, the employment of the inland waterway route involves two more transfers than the employment of a competing rail route.

8. In all three cases the terminal problem is essentially that of determining the character and quantity of freight to be handled, and based on these, of deciding what equipment in the nature of quays, wharves, piers, mechanical appliances, transit sheds, warehouses, yards, etc., should be installed in order to move the freight from land to water or from water to land with the least total cost, including in this cost the value of the time of the vessel or water carrier as well as the investment in and the operating cost of the terminal itself. It goes without saying that a costly terminal of large capacity and great intrinsic efficiency might prove wasteful for the handling of a relatively small volume of business, and that its low operating costs might be more than counterbalanced by the high fixed or overhead charges, including interest, depreciation, amortization, and insurance. In such a case a simpler, less expensive, and intrinsically less efficient device would be preferable, and in general it may be stated that nothing could be more damaging to the interests of water transportation than the construction and development of terminals disproportionately capacious and expensive, having regard to the volume and character of the traffic that they prove really able to command.

9. Harking back to our classification of water transportation, it is obvious that the competitive spirit is the active cause of the development of terminals and of the desire to bring them to a maximum degree of efficiency and economy. In the first class of water transportation the competition is in foreign trade with other continents, and therefore the traffic is necessarily water borne. We find as competing for the advantages of this trade, first, our own ports variously located, each of them anxious to attract as much as possible of the traffic and to derive from it the profits of all kinds, direct and indirect, known to result. Each such port therefore aims, or should aim, to afford service at the least cost to exporter or importer, and thereby to enable him to sell at the lowest price in the markets of his choice. Similarly there is competition between our ports and those of other countries engaged in dealing with markets not on this continent, all the ports doing their utmost to promote the trade of their nationals. Where other conditions, such as the cost of materials or labor, are substantially equal, the cost of transportation may be the determining factor in the

conquest of foreign trade, and it is the ultimate object of improved terminals to keep one important item of transportation cost at a minimum.

10. In the second and third classes of water transportation there is usually available an alternate rail route, and choice will generally be based upon the cost of taking the freight from the consignor at its point of origin, transporting it to its destination, and delivering it to the consignee. In the case of freight in carload lots the railroad spots the car at the warehouse of the consignor where it is loaded by him, and on arrival at destination the car is in due course spotted at the warehouse track of the consignee to be unloaded by him. In such a case the only terminal charge against the freight is the total cost of loading into the car and unloading from it. With modern warehouse equipment this cost should be low, and in any event the same charge must be incurred in case the water route is used for the same movement, and the warehouses at both origin and destination of the freight are actually situated upon the water front. In the great majority of cases, however, the water route is unfavorably situated so far as concerns terminal handling of general merchandise traffic in that the warehouses of both consignor and consignee are rarely on the water front. To get freight to the water carrier generally involves a haul by truck or by rail, in itself costly, and after delivery to the transit shed the freight must be moved thence to shipside and loaded into the hold. At destination these processes must be reversed, and they are obviously laborious, expensive, and disadvantageous to the water carrier. To keep terminal costs at the minimum involves the adoption of every labor and time-saving device that the ingenuity of terminal engineers can afford and the amount of traffic warrants. Even so, the distance between origin and destination must be great in order that the superior transportation economy of the water carrier may overcome these disadvantageous terminal conditions.

11. The preceding remarks apply to both the second and third class of water transportation, but the latter—inland water transportation—is often characterized by a further disadvantage, namely, excessive variations of water level such as prevail upon many of our rivers, often amounting to 50 feet or more. In such circumstances the extra transfers may be made even more expensive by the necessity of overcoming one or more vertical lifts of considerable magnitude.

12. If water transportation is to compete successfully with carriage by rail, it must not only use the most efficient carriers of design adapted to the conditions of the route, but it must also reduce every other cost, notably that of transfer, to its very lowest. Well planned, conveniently located, and highly equipped terminals will, where the volume of traffic justifies their installation, be essential, and the accompanying report, containing as it does descriptions and illustrations of terminal arrangements of many different kinds, will go far in helping those who are interested in arriving at correct decisions.

13. There should, however, be noted an exception to the broad statements already made, which are intended to apply almost exclusively to the transportation of freight in packages. Where bulk freight, such as iron ore, coal, or grain is involved, it is rarely the

case that the use of the water route necessitates more than one extra transfer. Thus, in the case of coal, to enable the product to be loaded upon cars, a tipple of some kind is always required, and the same thing is needed when barges or vessels are used in place of railroad cars. In the case of grain, at some stage in its journey it is always necessary to pass it through an elevator for cleaning, grading, and storage in anticipation of reshipment to the ultimate consumer. When the grain is shipped by rail, it must therefore be passed through the elevator, just as is usually necessary when grain is shipped by vessel. In other words, for bulk commodities, the disadvantage of the water route is sometimes less than exists in the case of package freight, and this is one reason why the water route is peculiarly well adapted to the transfer of bulk materials.

14. In closing, something should be added to emphasize the important bearing that the form of port organization and the method of port operation have upon our ability to compete successfully in foreign trade and with foreign carriers, as well as upon the economy of the water route as compared with the rail route. It is obvious that the water front of a port constitutes the connection between the port and the waterways and other bodies of water tributary to it just as the street system of the port city gives it access to highways leading to the land area lying inland. Unless the water front is publicly owned and controlled, the port may be deprived of convenient connection with the various waterways and water routes that naturally should center there, or at any rate there will be an absence of complete freedom to develop and improve such connections. Similarly, unless water-front improvements such as terminals are created, owned, and operated by the public, and progressively developed in pursuance of an intelligent policy based not necessarily on earning a direct profit but more usually upon the larger plan of promoting the general growth and prosperity of the port city, it is probable that the public interest will not be properly served, and that private motives or advantages of one kind or another will serve to prevent the port from achieving its highest usefulness. Experience shows that each port should be managed as a unit under competent public control, and that in making schedules of terminal charges the port authority should take into consideration the value to the community of such general benefits, such as any greater volume of business, increased employment, growth in taxable values that have resulted or are likely to follow from the construction of efficient and economical terminals.

15. We may well afford to emulate such examples as those of New Orleans, San Francisco, Seattle, in this country, and London, Liverpool, Manchester, Hamburg, and Antwerp in Europe, all of which have a progressive and continuous port policy under which terminals are owned, operated, and developed by the public through organizations representing the whole body of interested citizens, and private profit or merely selfish advantage has no place in the general scheme.

For the board:

C. KELLER,
Colonel, Corps of Engineers,
Resident Member of the Board.

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REPORT OF CAPT. F. T. CHAMBERS, CIVIL ENGINEER CORPS, UNITED STATES NAVY.

An investigation of the general subject of water terminals, with descriptions and general plans of terminals of appropriate types and construction for the harbors and waterways of the United States suitable for various commercial purposes and adapted to the varying conditions of tides, floods, and other physical characteristics.

1. House Document No. 652, Sixty-sixth Congress, second session, contains special reports giving for each river and harbor district of the United States the information specified under paragraphs (a), (b), and (c), and, in part, the information required in paragraph (d) of section 7 of the river and harbor act approved July 18, 1918, but contains little discussion of the appropriate design and construction of terminals suitable for various commercial purposes. The present paper has therefore been prepared to cover this part of the subject.

2. Conditions largely brought about by the Great War have materially changed the American viewpoint with regard to transportation. We have acquired an immense fleet of seagoing ships and propose hereafter to carry a full half, at least, of United States exports and imports in our own bottoms. The growth of our railway systems has been effectually checked during the war, and, as an after effect, railway finances are in no condition to permit the growth of railway systems and equipment required for normal times. It is therefore necessary to use the present equipment as intensively as practicable, and those who have given the subject the deepest study are convinced that if the water terminals can be designed, equipped, and operated in the most scientific manner, both ships and cars can be made to carry a largely increased amount of cargo per annum. They are also convinced that our navigable waterways should play a more important part in the problem of internal communication, thus sharing the function of the railways in handling our commerce.

3. The Board of Engineers for Rivers and Harbors in its efforts to carry out the will of Congress as expressed in the river and harbor act approved on March 2, 1919, section 500 of the act of February 28, 1920, for the termination of Federal control of railroads, and paragraph 53, section 8 of the merchant marine act of June 5, 1920, H. R. 10378, has made a considerable study of the water terminal problem, and has taken over in this connection the greater part of the work of the United States Shipping Board Port Facilities Commission. The latter commission and the Board of Engineers for Rivers and Harbors have been called upon, and have advised numerous United States port authorities in regard to their port problems, and this work is continuing. The board is compiling comprehensive port facilities data, with maps of the most important ports, and it is expected that these studies will from time to time as completed be published as separate documents, which will be of great use to the port authorities themselves, and to all those interested in water to rail and rail to water movements—this especially in view of the fact that the information collected is on the same basis for all ports.

4. The board has also made a very considerable study of terminals required for our navigable waterways, and has been engaged upon the design of such terminals, especially for rivers of greatly variable water level. It therefore feels warranted in saying, first, that, while

in certain instances local port authorities are progressive, with organizations containing engineers and traffic experts fully competent to carry out economic port design, and have in several notable cases done highly creditable work in this line, it is nevertheless a fact that in most instances in our seaport and large river cities those most directly concerned have little conception of economic terminal design. Many of them, while interested in the subject and alive to the fact that the possession of adequate terminals is essential to the development of traffic, have little idea how to begin. In fact, it is rather usual for those in control to believe that all that is necessary to attract business is to thrust a pier into navigable waters. There is too much copying and too little employment of competent experts.

5. In the very inception of the subject it is necessary to consider the character and amount of each commodity which it is proposed to handle. A terminal adapted to handling one material may be utterly unfit for another. The coal and ore docks of the Great Lakes have an approximate average complete turnaround for 10,000 ton bulk cargo vessels of 12 hours in upper lake ports and 24 hours in lower lake ports, but these terminals could not be used, nor are the vessels themselves fitted for package freight. On the other hand, terminals designed for the transshipment of package goods are at best poorly adapted to handling materials in bulk. The port, therefore, which hopes to succeed in water traffic must first investigate its tributary territory, and compile all possible information with regard to commodities available, the amount of each, and the dimensions of the various boxes, bales, crates, barrels, etc., used as containers. Then, as it is essential to successful business that return cargo be had, it must obtain similar information as to incoming commodities, their origin and their points of disposition. It must, furthermore, employ competent engineering talent, as port design is a specialty in which few competent engineers are to be had.

6. In a treatise of this nature it is scarcely to be expected that details of design can be much more than touched upon. There are standard works upon this subject, with which engineers should be familiar, and, as hereinbefore remarked, port design should not proceed without adequate engineering advice.

7. *Ocean terminals.*—Our subject naturally divides itself, first into ocean terminals, in its turn subdivided into terminals for bulk commodities, such as coal, ore, grain, petroleum, lumber; for package freight, such as bags, barrels, hogsheads, bales, boxes, cases, crates; and finally for such materials as do not require special containers. Under this head will come locomotives, structural-steel frames and shapes, wire in reels, pig iron, pig lead, and pig copper, dressed animals in quarters or whole, live animals, etc.

8. Under this general head of ocean terminals it will be necessary to discuss tidal and flood conditions and their effects upon design; also types and materials of construction and, in outline, construction details. The mechanical equipment of each class of terminal will be considered in this design.

9. *Interior waterways.*—The second grouping will, under the general head of interior waterways, include the Great Lakes, canals and rivers of small tidal or flood range, and rivers of large flood range. Under each subhead it will be necessary to discuss the subject of suitable mechanical equipment. Indeed, this matter of mechanical

handling equipment is highly important to all classes of terminals, and in water-terminal design it should be constantly borne in mind that no part of the transfer should be done manually, unless it has been determined that mechanical equipment can not economically be adapted to the purpose in view. So far as our ocean terminals are concerned, it is believed that the economic terminal will be one of the greatest factors in the success of our merchant marine, and that without the most efficient handling of freight between our railroads and our interior waterways these waterways can not succeed except in those few cases where there is no railroad competition.

OCEAN TERMINALS.

10. *Sheltered location necessary.*—A water terminal, for whatever purpose designed, must be located upon sheltered waters. This shelter may be provided by a natural conformation of the seacoast, such as a bay or harbor, or by a river estuary, or the terminal may be located at some distance inland upon the bank of a navigable stream. Again, the shelter may be provided in part, or as a whole, by artificial breakwaters or jetties. The seacoasts of the United States are plentifully provided by nature with sheltered harbors for all ocean business likely to be transacted. In some instances, however, it is necessary to supplement the provisions of nature by means of breakwater or jetty constructions, either for the purpose of harbor enlargement or to obtain and maintain deeper water. The sheltered waters may be said to constitute the harbor.

11. *Ports.*—A port may for our purposes be defined as a harbor so improved as to offer facilities for the transaction of business between ocean and land carriers. The word may be used to designate an entire harbor improved for the transaction of such business, as, for instance, where we speak of the port of New York, thereby including both the New York and New Jersey shores; or the word may be applied to indicate one terminal development within the harbor.

12. *Terminal facilities.*—A well-equipped port will provide pilotage where necessary, tugs for towing ocean vessels to their berths, anchorage for vessels not requiring to be berthed, with access to shore, piers or wharves, open or covered, affording direct connection between ocean and land carriage, storage facilities ranging from open-ground areas for bulk materials which will not materially deteriorate from weather exposure, to loft buildings for the protection of perishable cargo, coal and oil storage, with supporting piers or lighters affording bunkering facilities, repair shops and dry docks with the necessary capacity and equipment for overhauling and repairing ships, lighters, and car floats for the transfer of cargo from various points in or near the harbor to and from ships, accommodations for the direct access of trucks, and in some instances for canal and river craft, and, most important of all, railroad tracks and yards properly located and adequately provided with trackage for storage and transfer of the many full and empty railway cars necessary to handle to and from ocean-going ships the freight which makes up their cargo.

13. *Tides and floods.*—At many European ports, notably the principal ports of Great Britain, such as London and Liverpool, the tidal

range is so great that it has been found necessary to construct basins in the foreshore of the harbor and to provide them with locks in order that ships may be conveniently loaded and unloaded in waters at a fairly constant level. At Liverpool, for instance, the natural range of tide is 33 feet. Under such circumstances the difficulty of loading and unloading at a quay directly exposed to the tidal range may readily be visualized. In the United States, however, the tidal range at our principal ports varies from a few inches, as at some of the Gulf ports, to perhaps 15 feet, as at some Puget Sound ports. It is true we have river ports where flood conditions cause a wider variation, as, for instance, at Portland, Oreg., with a range of about 30 feet, but in no instance has it been found necessary to construct basins behind locks. That our practice in this respect corresponds with that of the British is indicated by the fact that at Newcastle-on-Tyne, with a variation at spring tides of 15 feet, it has not been necessary to use the lock system. This system is expensive, as it requires a large amount of excavation protected by expensive masonry locks and gates. It further has the disadvantage of limiting communication between outer harbor and inner dock or basin to slack water of high tide, so that vessels must frequently incur expensive delays while awaiting access to a berth.

14. *Anchorage.*—Every harbor worthy of the name should, of course, provide ample anchorage area for the accommodation of shipping. The harbor may be used by ocean-going vessels which have simply run in to escape a storm and to await better weather or ships may while swinging at anchor discharge imports and take on exports. At many harbors throughout the world there is no other shore provision for the transfer of cargo between land and water than small piers or wharves having sufficient water alongside for the accommodation of shallow-draft lighters. Cargo can indeed be transferred between ship and lighter with great expedition, and in certain climates and with some kinds of commodities economical results can be obtained, but such a system of transfer between land and water involves at least one extra handling, and extra handling is a cause of expense that we must avoid. Railroad freight in carload lots, because the cars can be switched from one railroad system to another without breaking bulk, can be transferred over long distances—in some cases hundreds of miles—for the cost of a single transfer or handling of that same freight. If such railroad freight had to be handled from car to car at the end of each railroad system, the cost of transportation would become so great that long-distance transportation of many commodities would be entirely prohibited. In degree the same reasoning applies to lighterage transfer. Package freight, for instance, should not in general be exposed to inclement weather, and there is never a guaranty that cargo placed upon a lighter will be transferred immediately to the ship's hold. On the other hand, should covered lighters be used, the cost of transfer will be much enhanced. It may be said in general that lighterage transfer to ships at anchor is only economically applicable at a port where few ship cargoes are handled per annum or in cases of emergency where congestion of the water front prevents a ship from obtaining a berth.

15. *Fore and aft moorings.*—In some ports lines of mooring posts or dolphins are constructed in the middle of the stream or slip,

H
V

and ocean-going vessels are moored fore and aft to these supports, which usually consist each of a group of timber piles drawn together at the top and lashed together by means of chain or wire cable. Such moorings are economical, so far as first cost is concerned, but are only applicable where they can be constructed in line of the tide or in still water behind locks. They are particularly indicated for the transfer of bulk cargo, such as grain, between ocean carriers and lighters or canal boats, where such boats are the means of long-distance transfer to inland waterway points.

16. *Locks and basins.*—As explained in paragraph No. 13, these are principally applicable to ports where the tidal variation is large, and for United States ports the extra expense of such construction is not justified. An excellent example is furnished by the Victoria and Albert Docks at London. (Fig. 1.) These docks have been constructed at a bend of the River Thames, the system having locks at both ends connecting with the river. This system also furnishes an excellent example of modern tendencies in dock construction. The Royal Victoria Dock is the oldest of the system, and it will be noted from the figure that it is about 2,000 feet wide, with comparatively narrow piers projecting from one side, with the idea of accommodating one ship on each face of each pier. As ships vary in length and are constantly growing in size, such piers are not economical, in that it is impossible to say what length will be required at any particular time. As will be further demonstrated hereafter, they are also uneconomical in that they seldom provide sufficient storage area for the rapid dispatch of vessels.

17. The Royal Albert Dock, of more recent construction, is, on the other hand, less than 500 feet wide, but much longer than the Victoria Dock, and a glance at the illustration will show that a maximum number of ships can be accommodated on either side of the basin, as such ships may be moored stem to stern for the entire length of the quays, regardless of individual length. Furthermore, it will be noted that whereas the piers in the Royal Victoria Dock are not provided with direct access to the railway, the arrangement at the Royal Albert Dock is almost ideal in this respect. The transit sheds in this instance accommodate ships on one side only and have the railroad system on the other side, thus affording the shortest practicable haul between railway car and ship and providing such width for transit shed as is required to take care of maximum cargo.

18. The Royal Albert Dock South, now being completed, gives further illustration of the principle above noted. Its transit shed and railway system had not been constructed at the time the plan was made, but the indications on the north side of the basin point to construction closely following the details of the original Albert Dock. The south side of the Royal Albert Dock South is provided with a so-called jetty system, the English nomenclature being different from the American in this particular. In the United States the term "jetty" is usually applied to a narrow training wall or breakwater construction, whereas in England the name is applied to a narrow pier or wharf, generally parallel to the shore but detached from it, or only connected to it at one end. In the plan adopted for the Royal Albert Dock South each so-called jetty consists of a narrow, open-work structure, spaced only sufficiently far from the edge of the

quay to provide for canal boats and barges, the width of the jetty being just sufficient to support tower and jib cranes of sufficient reach to place ashore material from a ship lying along the outer line of the jetty or from a barge lying between the jetty and the quay. This system is applicable at London because of the many canal boats and barges plying between the London docks and the numerous interior canals. The jetty system, so constructed, allows canal boats and barges to be moored along both sides of the ship, so that operations of loading and unloading may proceed at double speed.

19. While it is unnecessary to adopt the locked basin in this country, a valuable lesson may be learned from the arrangement of the quay system, most particularly with regard to the relative position of ship, transit shed and railway, the economy of space for cargo, and its direct movement.

20. *Docks, quays, wharves, and piers.*—The designation of the shore accommodation for ships in American harbors is the cause of much confusion, especially when compared with English practice in this respect. The word "dock" in England, and in fact, in continental countries, is applied to the water area, and this is the proper usage, but in the United States this word "dock" is applied indiscriminately to the construction along the shore of navigable waters or to a projecting pier, and the word "wharf" is used in a similarly confusing manner. On the Great Lakes, for instance, the common term applied to the facility for discharging bulk material is "ore dock" or "coal dock," whereas, in many instances at least, a pier or wharf is meant. The word "quay" is seldom used in this country in common parlance, but should be applied to a paved area bounded by solid construction, usually of masonry or masonry and timber, which parallels the water front. The word "wharf" is properly applied to an open construction, usually of timber, also parallel to the water front; the word "pier" to any construction projecting at a considerable angle, usually at right angles, into navigable waters, and usually provided with two docking sides or edges.

21. *Open or uncovered terminals.*—For direct transfer between land and water the simplest construction is the open or uncovered quay, wharf, or pier. Such a terminal may be built paralleling the water front or projecting into it. It may depend entirely upon ship's gear for loading and unloading or it may be equipped with mechanical handling devices of its own. It is only applicable to materials which are not to any great degree affected by inclement weather, such materials being coal and ore, rough lumber of the commoner kinds, exclusive of the principal hardwoods, naval stores, structural steel, pig metal, etc. Open terminals may be provided with highly specialized machinery for handling a particular material, such as coal or ore.

22. Figure 2 shows an installation on the Great Lakes at Duluth for the dumping of iron ore. It consists in the main of a high trestle with bins, over which bottom dump railroad cars are run, the material dumped, and by means of chutes conveyed directly into the holds of especially constructed coal and ore carrying vessels. As hereinbefore noted, the complete turn-around in upper lake ports of such vessels is approximately 12 hours.

FIGURE 2

FIGURE 3

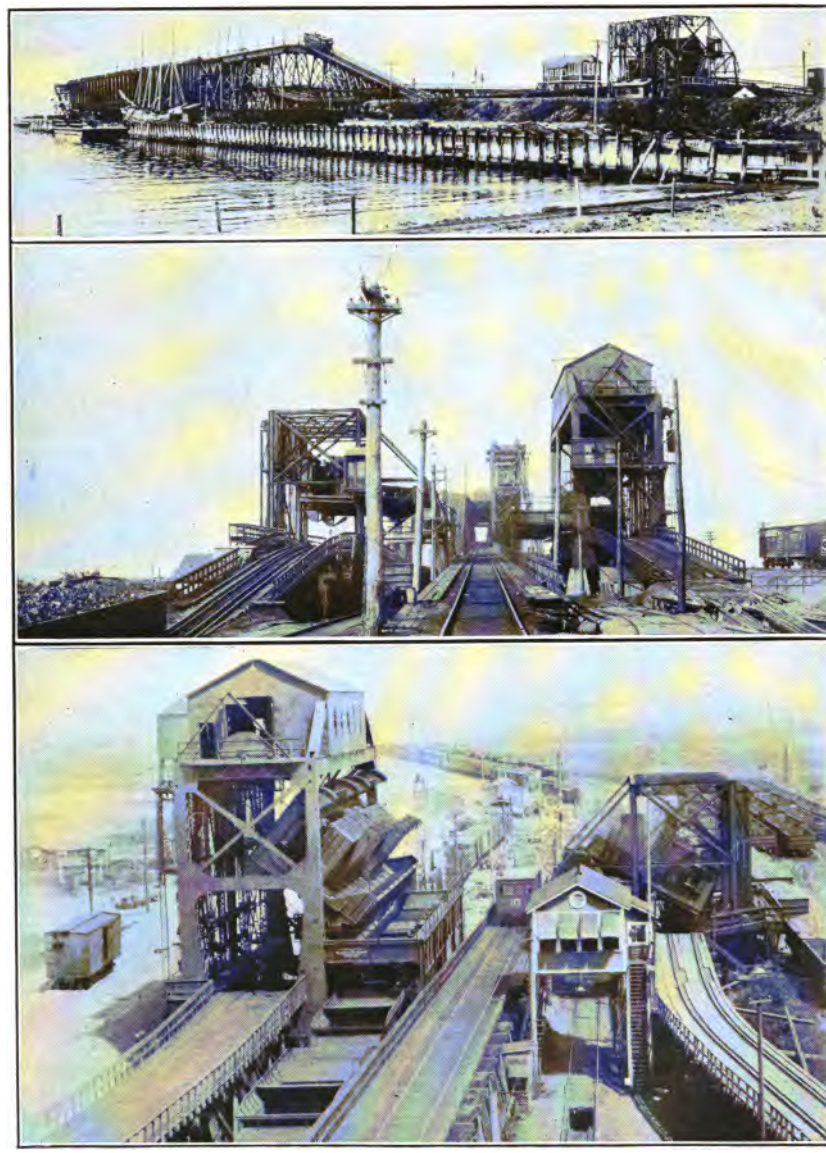


FIGURE 4

23. Figure No. 3 shows an ore-reclaiming plant at Cleveland, Ohio. It is stated that when the business of handling ore at this point was first started, such transfer being accomplished by men shoveling the ore into wheeled carts or barrows, the cost was approximately 50 cents per ton. Now, with especially constructed lake vessels and with installations similar to the one shown, the usual time in port of an 8,000 to 10,000 ton carrier is about 26 hours, and the operating cost per ton of handling ore about 4 cents. A battery of such unloaders is set to work upon each vessel; and handling as much as 10 tons each for a single transfer operation between ship and railroad car, practically the entire cargo, within 2 or 3 per cent, is transferred without man power, except such as is required to operate the highly specialized machinery. With such equipment, ashore and afloat, it may readily be understood that there is no question of rail competition for this business.

24. A highly successful ocean terminal for the transfer of coal from railway car to collier is shown by figure 4. The Virginian Railway is essentially a coal-carrying road, and economic transfer is important, the capacity of the Sewalls Point plant at Norfolk, Va., being approximately 500,000 tons per month. The plant consists of a pier of steel construction 1,025 feet long, 77 feet high, and 65 to 73 feet wide, of which 825 feet of the inshore end is used for the loading of ships. The coal comes from the West Virginia mountains, and in wintertime is frequently frozen in the car to such extent that bottom-dump equipment could only be used after first thawing the frozen mass. The railway management, however, anticipated this condition and most of its cars are of the gondola type. Under these circumstances car dumpers are used. One of these machines picks up one car at a time; the other, two at once. The cars are run upon the platform of the hoist, securely clamped to the lifting and dumping arm, and then turned bottom side up into especially constructed, electrically operated hopper-bottom cars of 55 tons capacity each. These cars are then run to the back of the elevated structure of the pier, and either boosted to the upper level by means of a cable hoist equipped with a so-called "barney," or they are loaded upon an electric elevator which hoists the pier cars vertically to the top of the pier, where they operate under their own power and deliver the coal to the required pier hopper, to be conducted by chute to the hold of the receiving ship. With such a plant it is necessary to have sufficient railway yards to accommodate the maximum number of full and empty coal cars required daily, plus a reserve sufficient to take care of delayed railway deliveries. The plant is essentially for shipping purposes, and there is no provision for storing cargo other than that held in railway cars.

25. Figure 5 shows the coal terminal at Curtis Bay, Baltimore, Md., of the Baltimore & Ohio Railroad. This plant also uses car dumpers, but its method of operation is entirely different from that of the Norfolk plant. The car dumper discharges into a hopper which feeds a continuous-belt system, which runs longitudinally upon the coal pier. Located on the pier are movable machines with a traverse of the entire berthing limit of the pier. One of these machines is set opposite the hatch of the ship to be loaded. The longitudinal belt has a tripper arrangement which trips the coal on to

an elevating belt running at right angles thereto, which in turn feeds a chute, which directs the coal into the hold of the vessel. This chute is provided with a special centrifugal distributing device which throws the coal the full length and width of the compartment, thus entirely avoiding hand trimming. The capacity of this installation is very large, and if the plant is kept constantly busy it is doubtless quite economical. Compared with the Sewalls Point, Norfolk, plant, it has the disadvantage of many more moving parts and of a large area of very expensive rubber belting continually exposed to the elements. Such belting deteriorates about as fast when out of use as when constantly busy. In consequence, it may be said that the system in general is not as well adapted to intermittent use as the Norfolk design of elevated pier and car dump.

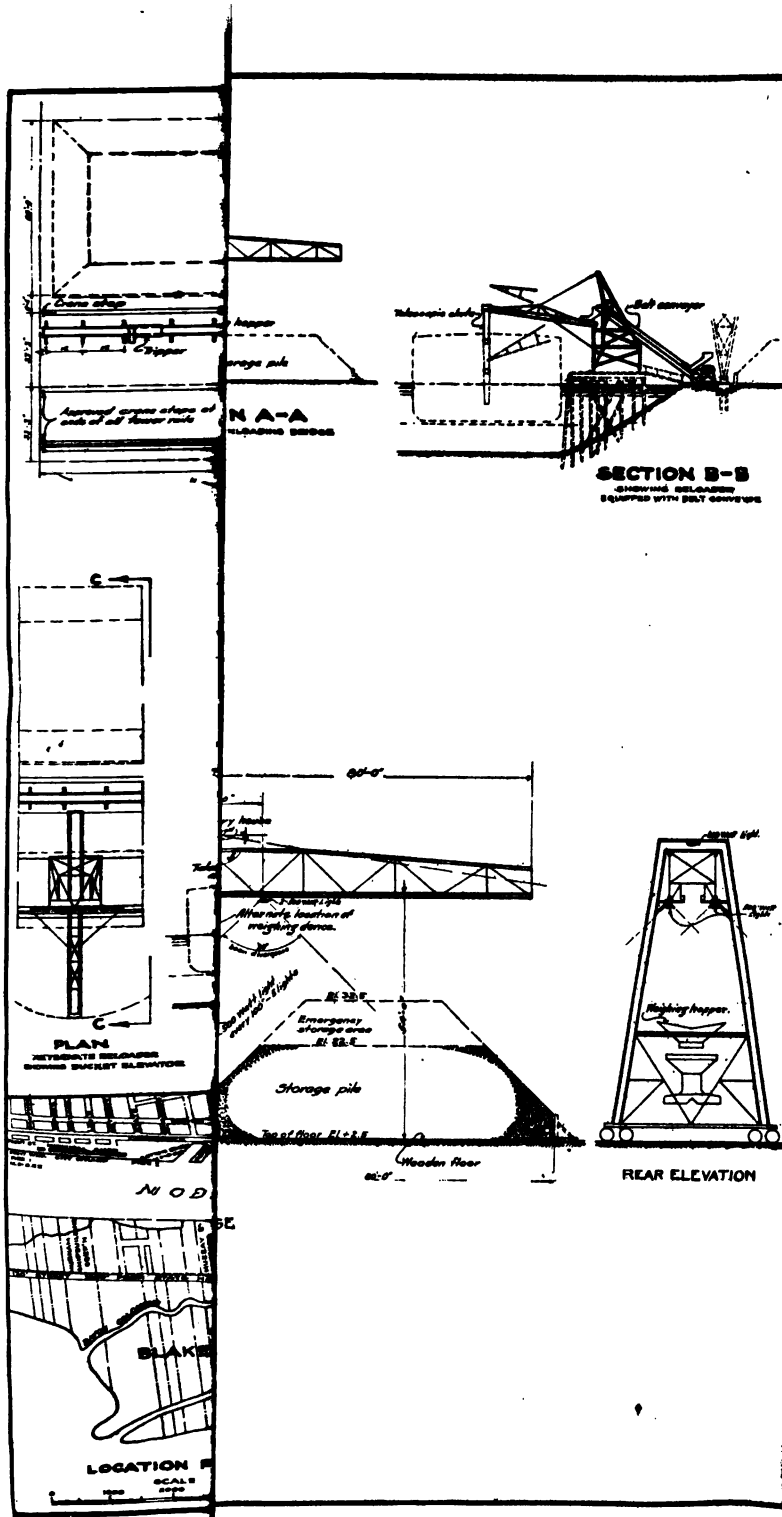
26. *Ground storage for materials in bulk.*—The bulk terminals so far described are adapted only to the direct transfer of such material between car and ship or ship and car. There are many instances in which it may be necessary to store the bulk material in large quantities before shipment. In such cases careful design is required in order that extra handling may be reduced to the smallest practicable expense.

27. Figure 6 shows a water-front quay for the accommodation of a ship. Along the front of the quay are located the necessary railway tracks for the accommodation of cars for the convenient transfer between ship and car of coal or ore for transport. Directly behind the railway tracks is open ground storage for coal or ore. The whole area is spanned by large gantry bridge cranes running parallel with the water front and furnishing at right angles thereto a runway for a 6-ton clamshell bucket with a man trolley. The operation of the whole device is electrical, and the trolley carrying the bucket is capable of traversing at a speed of 800 feet per minute. In operation the clamshell bucket is lowered into the hold of the vessel; the bucket automatically closes upon a load of 6 tons, is lifted and traversed over to the hopper which feeds the railway cars close to the face of the quay, or, when cars are not available, the load is carried to the rear of the tracks and deposited upon the storage pile. The capacity between ship and car may be very large, as the haul is short. This capacity is considerably reduced when the material must be stored in the pile. In the operation of unloading the ship the material would be carried the shortest practicable distance, or to the near edge of the storage pile, there dumped, and later redistributed by the gantry bridge crane when the vessel has been dispatched.

28. *Ocean and inland waterways terminals.*—Figure 7 shows a design by the Board of Engineers for Rivers and Harbors for a coal and ore terminal at Mobile, Ala. The terminal is to be located upon Blakeley Island, opposite the city of Mobile, where there is no railroad connection. It is to handle coal from the Alabama fields, brought down by river barge, or ore brought in from South American and Cuban ports by ship. The amount of money available for this terminal was quite limited, and the design may be considered the best effort of the board to secure a suitable terminal for $400,000 at 1920 prices. The terminal consists in the main of a creosoted timber wharf 500 feet long, supporting the front leg of a gantry bridge crane, the back leg of which is supported upon a concrete structure which also forms the front wall of the open storage area. The gantry

FIGURE 5

FIGURE 6



8°—H. Doc. 109, 67–1. (To face page 18.) No. 2

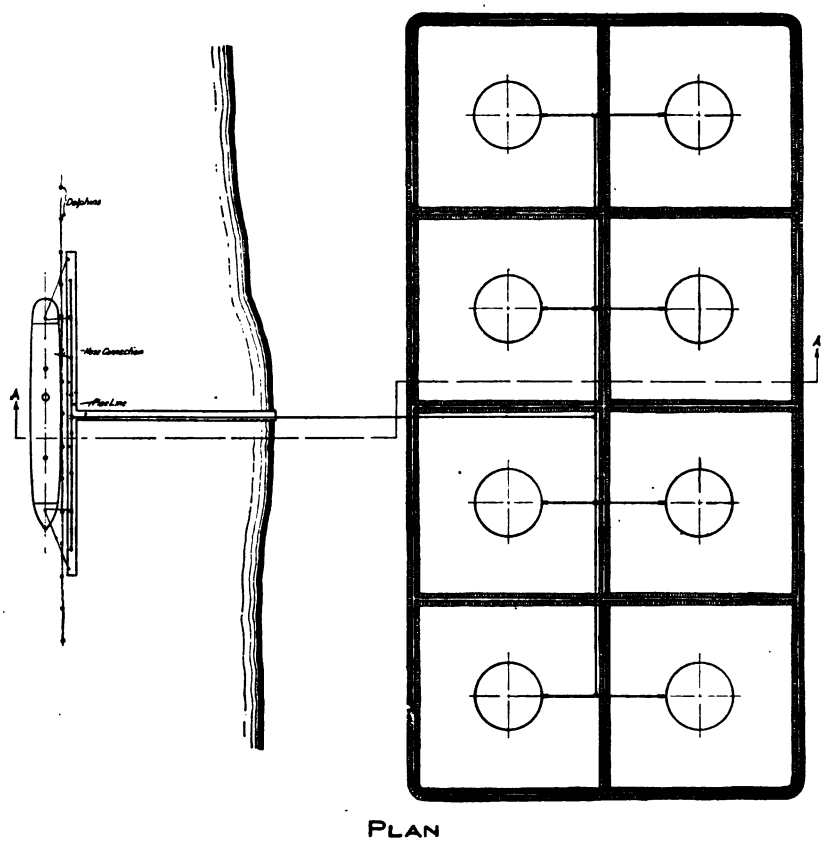
bridge crane runs on tracks for the full length of the wharf, which provides a berth 500 feet long for a ship drawing 30 feet of water. It is equipped with a 4-ton clamshell coal bucket which runs at right angles to the water front, and thus is enabled to cover the entire width of the storage pile. In this instance it was necessary to provide for four different qualities of coal in separate piles, and also a separate area for ore. Thus it became necessary to find economic means for the transfer of coal in the pile at any point of the open storage to any hatch of the collier to be loaded. A longitudinal belt system, parallel with the water front and just in front of the track runway for the land leg of the gantry crane, is therefore arranged to be run in either direction and to trip its load at a movable reloading tower so constructed that when its outboard swinging arm is turned parallel with the water front the tower can be traversed under the gantry crane. This tower is therefore capable of being operated at any point on the entire water front. In the operation of unloading the river barge it is necessary for the bucket to traverse from the barge to the coal pile. The speed of unloading the barge is guaranteed at 400 tons per hour. The detention of a river barge is unimportant as compared with the detention of an ocean-going ship. The operation of loading ships is as follows: The operator will have redistributed the coal in the pile when no vessel is in port, so that he will have plenty of coal close to the inboard leg of the gantry. This inboard leg supports a weighing hopper, which in turn feeds into a hopper which discharges upon the automatic belt. The travel of the clamshell bucket in loading the weighing hopper will therefore be the shortest practicable, and as the belt system operates continuously the longitudinal belt feeding the belt of the reloader, the limit of speed of the design is that of the clamshell bucket in handling material between the stock pile and the hopper. As will be seen by the illustration, the longitudinal belt feeds an inclined fixed belt on the reloader, which in turn feeds a movable belt, which may be both elevated and also swung laterally, this belt in turn feeding a telescopic chute, which by hand manipulation may be caused to distribute the coal so as to avoid hand trimming. The rate of loading ships is also guaranteed at 400 tons per hour. For loading ore it is proposed to use the bridge crane with a special clamshell bucket only and not the belt system.

29. *Other open or uncovered terminals.*—Open terminals are also adapted to the handling of lumber, naval stores, structural steel, pig metal, and similar materials. They may under such circumstances consist simply of an open-decked wharf or pier, with no handling apparatus other than hand trucks or similar devices, dependence being placed upon the ship's gear for all lifting; or the dock or pier may be provided with especially devised cranes for handling the material.

30. Figure 8 shows the Erie Railroad pier at Weehawken, N. J. The cranes shown are capable of handling such materials as lumber, structural steel, or any reasonably heavy package which can stand exposure to the weather. The pier is intended for the transfer of material between flat or gondola cars and ships or lighters.

31. Naval stores, such as rosin, are usually stored in the open and, on account of the many grades in quality and the many marks, a large area is required, so that, generally speaking, it is not prac-

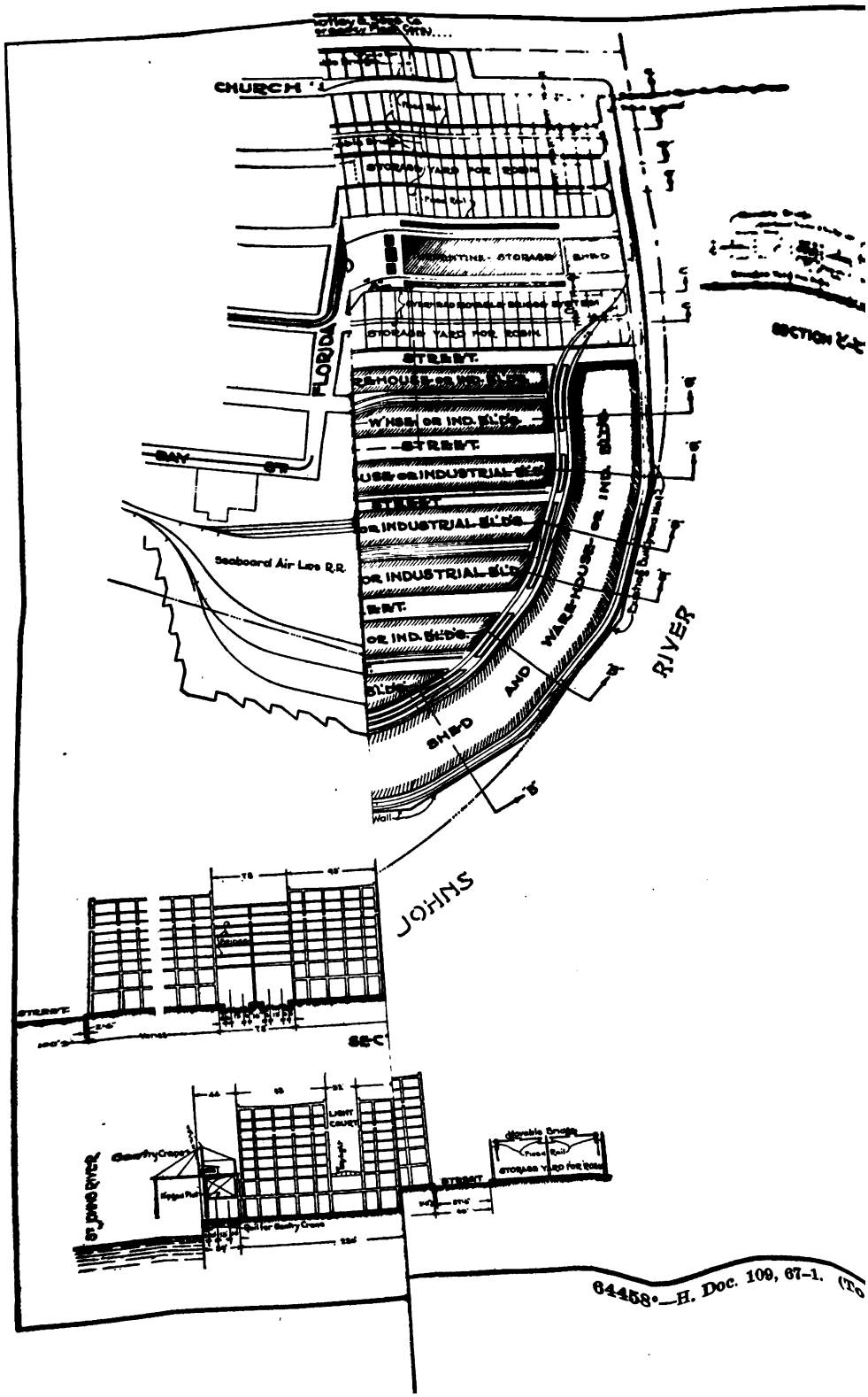
ticable to place all of the barrels close to the water front. Figure 9 shows a design for a terminal at Commodores Point, Jacksonville, Fla. While the greater part of this design is for covered storage,



SECTION A-A

Figure 10.

the upper part of the figure shows the area to be devoted to the storage of rosin. By means of a movable bridge, traveling on parallel tracks at right angles to the water front, a loop system is created,


CHURCH ST.
STORAGE YARD FOR CRATES
PAINTING - STORAGE SHED
STORAGE YARD FOR CRATES
FLORIDA
STREET
WAREHOUSE OR IND. BLDG.
WAREHOUSE OR INDUSTRIAL BLDG.
BAY ST.
Seaboard Air Line R.R.
WAREHOUSE OR IND. BLDG.
AND
SHED
RIVER
JOHNS
SECTION C-C
ST. JOHNS RIVER
Gantry Crane
LIGHT
CAISSON
STREET
Movable Bridge
Track Rail
STORAGE YARD FOR CRATES

upon which an electrically operated tractor trailer trolley is designed to operate. In this manner the entire open area is covered and all the material can be delivered within reach of the gantry cranes which traverse the water front, and thus transferred mechanically from storage area to ship.

32. *Covered terminals for material in bulk.*—Commodities in bulk which need protection from the elements usually require special construction for each different class of cargo. Such material as fertilizer, it is true, may be stored economically in the same general class of covered building as some other material, such as coal. On the other hand, separate and special details of construction are necessary for each such material as petroleum, grain, etc.

33. *Storage for liquid material in bulk.*—A single special class of terminal is used for petroleum and the various mineral-oil products into which it may be divided, vegetable oil, molasses, etc., which are stored in tanks within a convenient working distance of the water front, the group of containers being designated as a tank farm. These individual tanks are connected through a pipe system with the improved water front where the ocean tanker is to be berthed. Most such terminals are provided with berths of extremely simple design. It is only necessary to have a line of pile dolphins at, say, 50 feet spacing, driven along the water front where sufficient depth of water is available. Behind the dolphins a footwalk of simple pile bents is constructed to furnish first a support for the pipe system, and, second, a walkway to permit those in attendance to handle lines between ship and mooring. Such an arrangement is shown by figure 10. Flexible connections of special type are provided between the outlets of the pipe on the wharf and the ship. The general topography of the particular site will determine the character of the pumping system which must be used to fill the tanks and to withdraw the liquid for bunkers or reshipment. In the simplest cases the oil tanker's own pumps will withdraw the oil from the vessel's hold and pump it into the tanks ashore, and oil bunkers will be obtained by gravity from these tanks. More elaborate pumping systems are frequently required, and in many instances a pump house and especially designed pumps for oil or molasses must be installed. Also, for the handling of such heavy oil as that which comes from Mexico, pipe coils will be required in the tanks and a steam-boiler plant to supply steam for heating the material to a temperature at which it will flow readily.

34. *Fire protection.*—Where the material to be handled is oil or gasoline, safety requires that proper provision be made against fire and the spread thereof. Perhaps the most efficient means commonly employed for the extinguishment of fire already started in fuel-oil tanks is the foam fire protection system. This consists essentially of a pair of especially lined tanks, one containing an acid solution, the other a solution which, when brought in contact with the acid, will form a large volume of foam. Pipes lead to a funnel or funnels in the top of each tank, the nozzles or ends of the pipes being brought together so that when the system is turned on, which is usually done automatically by thermostatic means, the funnel will act as a mixing chamber and the foam be released to spread over the entire surface of the oil, thus smothering the fire. Another system more recently pro-

posed replaces the oil, as used, by water let into the bottom of the tank. The oil tank is thus kept entirely full of oil or oil and water. The difference in gravity between the oil and water prevents the two from mixing, and the water further acts to scour the tank, so that there is not the usual deposit of sediment. As the tank is kept full at all times there is no mixture of air and gas at the top to ignite and thus set fire to the contained oil. On tank farms it is usual to surround each tank with an earthen fire wall, 5 or 6 feet high, and set at such a distance from the tank that its entire contents will be contained within the earthen fire wall should an explosion occur and the oil be released from the tank. Otherwise burning oil might be spread over adjacent land and water with disastrous results.

35. *Grain elevators.*—While much grain is shipped in bags, by far the greatest proportion is handled in bulk. The grain business of the United States is essentially one of export. The grain comes to the ocean terminal in box cars, with or without bottom doors, and must be elevated into special containers for discharge to ships. Such grain elevators, as the buildings for this purpose are usually called, contain special machinery for cleaning grain, as well as bins for its storage. In all elevators of modern type the grain is handled mechanically from the moment it leaves the car until it is delivered aboard ship. It may be dumped through doors in the floor of the box car into a hopper beneath the track, or the car may be tipped by special device, and the grain thus discharged from the car to the hopper. In most elevators the hopper into which the cars are discharged feeds a chain belt bucket appliance, which in turn feeds an endless belt running horizontally, or approximately so, and delivering to the various bins.

36. Figure 11 shows a modern grain elevator at Portland, Oreg., with its wharf connections. The bins in this case are cylindrical and of reinforced concrete. To load a ship the grain is released upon a belt system running through an inclosed gallery to the wharf at the water front where it supplies another belt similarly housed and running longitudinally at the front of the wharf. The belt at the water front is given sufficient elevation so that discharge may be had by gravity through chutes to the ship's hold. An automatic tripper is set at the desired point of discharge for deflecting the grain into the chute. The relative location of the shore storage will vary in different cases in accordance with the configuration of the land, the supporting power of the soil, etc. The above description is sufficient to give a general understanding of this form of construction.

37. Where the grain is imported the operation is reversed, and it becomes necessary to provide special means for unloading the grain from the ship mechanically. This may be accomplished by a suction device, usually erected upon a float, and thus available at any point in the particular port in question, or special portable frames containing endless chain belt buckets may be suspended by the ship's gear, or by wharf crane into the hold of the vessel for the purpose of excavating the grain. Such portable sections are equipped each with its own electric motor and also with a spout. The buckets on the chain belt dredge the grain from the hold, elevate it and dump it into the spout, which in turn discharges either to a lighter or ashore.

38. In figure 12, showing a type of construction at Manchester, England, it will be noted that the cross-section of the quay shows a

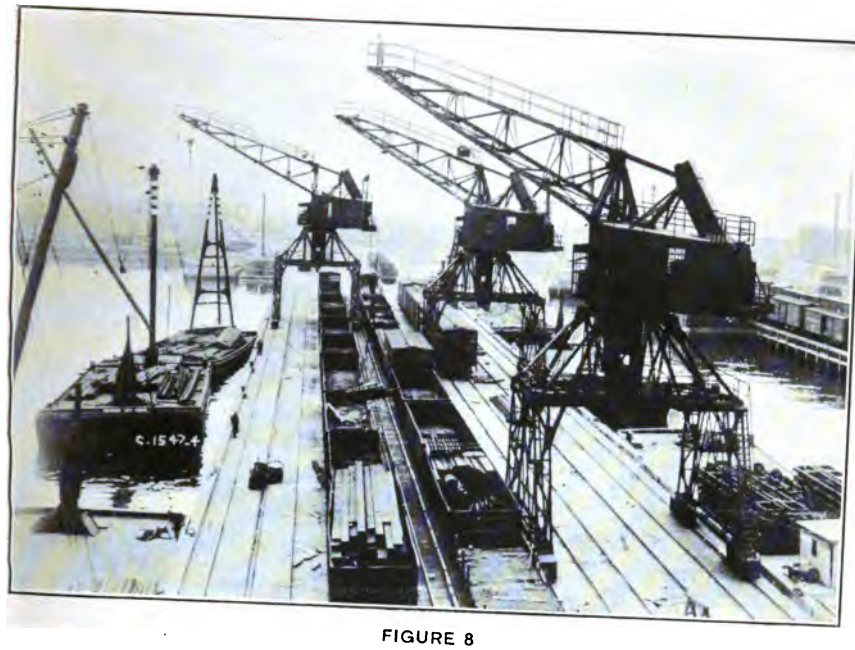


FIGURE 8

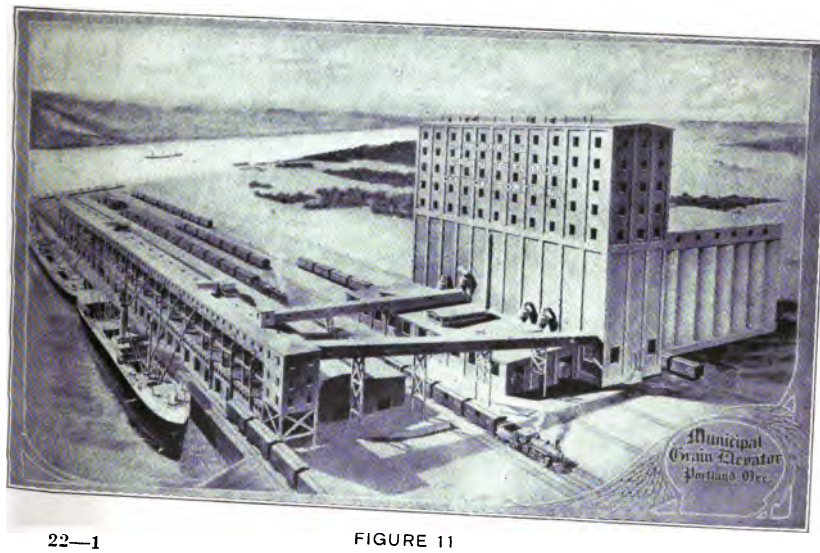


FIGURE 11

tunnel designated "Grain subway." By referring to the plan on this same figure it will be seen that at the head of Dock No. 9, which is 2,700 feet long, there is a grain elevator extending entirely across the head of the slip. It will thus be understood that any ship lying along the 2,700 foot quay on the south side of Dock No. 9 may discharge package cargo by means of its crane system into the transit sheds which line the quay, and, by means of the portable mechanically operated chain belt bucket units, at the same time discharge grain into the grain subway, which has, in its top, manholes provided for this purpose. Running horizontally the full length of the grain subway to the elevator are wide, endless rubber belts which discharge upon other belts, feeding fixed chain-belt bucket elevators, and the latter carry the grain to the tops of the bins. The Manchester elevator is modern in every particular and is especially well provided with both water front and railway connections. The railway tracks may be noted on the plan.

39. *Covered terminals for miscellaneous or package freight.*—The most difficult problem of the terminal engineer is that of designing for the economic transfer of miscellaneous cargo. Such cargo is generally known as package freight, and may range from automobiles, airplanes, machinery, furniture, pianos, etc., in crates, through the many variants in containers, such as hogsheads of tobacco; bales of cotton, jute, oakum, wool, hides, or hay; barrels, as of oil, apples, bottled water; boxes or crates of canned goods, dry goods, soap, fresh fruit, arms, or hardware; bags, as of sugar, salt, coffee, cement, flour, meal, grain, or potatoes; or, while not strictly to be classed as packages but essentially in the same category, such items as locomotives; structural steel frames, shapes, bars, rails, pipe; wire in reels; pig metals; beef in quarters; sheep (dressed); live animals, etc. If such shipments were uniform in character—if, for instance, the entire vessel were to be loaded with cargo of any one of the above-indicated kinds, the problem in the main would not be quite so difficult. But when it is understood that a miscellaneous cargo may, and usually does, contain many of these items in varying quantities, often consigned to several different ports, the scope of the problem of economic handling may be realized. Mechanical handlers of various capacities and descriptions have been used with greatest economy in our progressive factories for many years past, and the use of such equipment is increasing with the cost of labor. The variety of such apparatus is great, and in many instances it is directly applicable or may easily be adapted to the handling of package commodities at terminals. Unfortunately, the quantities of the various commodities are so variable that it is difficult to provide a sufficient variety of mechanical appliances, or, where these are provided, to set them up economically for use. We have seen that the terminals for special commodities, such as grain, can be so constructed that all handling will be mechanical, but the design of a terminal for miscellaneous package freight is an entirely different matter. This subject of mechanical handling will be taken up hereafter.

40. *Types of construction.*—Of the materials enumerated under the general head of miscellaneous cargo all but a few, such as structural steel, pig metal, etc., require protection from the weather, and this section deals, therefore, with covered terminals. We have

already dealt with open terminals and the materials for which they are used. Economic handling requires that the relationship between the ship's berth, the covered storage for freight, and the railway trackage be the simplest and most compact practicable. The tendency in the United States has been far too much toward the construction of narrow piers, with single-storied sheds thereon. While we should not copy blindly, it seems wise to inform ourselves as to the practice of those who are most experienced in the shipping business and to take from them what is good and improve it where we can. As already remarked, all terminal operations are expensive as compared with the cost of line haul or ocean transport, and our problem is to reduce this terminal expense to a minimum. Beyond a doubt, certain ports are unable to find funds for the investment required to secure the terminal plant to reduce the ship's stay in port to the smallest number of hours. Such ports necessarily fit their terminal design to available resources. We must, however, here assume that, within reasonable limits, money will be available for the provision of the really economical terminal. Before taking up the question of design it seems best to give consideration to present practice, and to illustrate such practice with reproductions of piers, wharves, bulkheads, and quays now in existence.

41. *Piers.*—In the United States by far the greatest percentage of berthing space for ships is in the form of piers, and beyond a doubt the present tendency to comparatively long and narrow piers is a growth from conditions natural enough in the past, but now so far modified that those contemplating water-front improvements should weigh the facts carefully before deciding upon such construction. The pier has an advantage over the wharf or quay construction in that it furnishes two berths, one on each side. Thus where little water front is available a much larger number of berths can be constructed upon the pier system than upon the quay system. It has the disadvantage that projecting at right angles, or nearly so, into the stream it is difficult to maneuver vessels into or from their berths except at slack water, with the further disadvantage that for modern ships of large capacity there is in general not sufficient width opposite the ship's berth for the accommodation of the enormous quantity of cargo which must be handled in and out. Piers of moderate width are quite suitable for fitting out berths for ships at a shipyard, or even for accommodation of cargo of small vessels, but it should be borne in mind that within the past few years the sizes of ships have increased enormously, and that it is now considered that for overseas business ships of 10,000 tons dead-weight capacity are the most economical. As ships grow in length, they grow also in beam and molded depth, so that the cargo-carrying capacity increases at an enormous rate. To illustrate this point the table below gives the characteristics of a 3,550 dead-weight ton steel ship, and alongside it the similar characteristics of a 12,000 dead-weight ton steel ship:

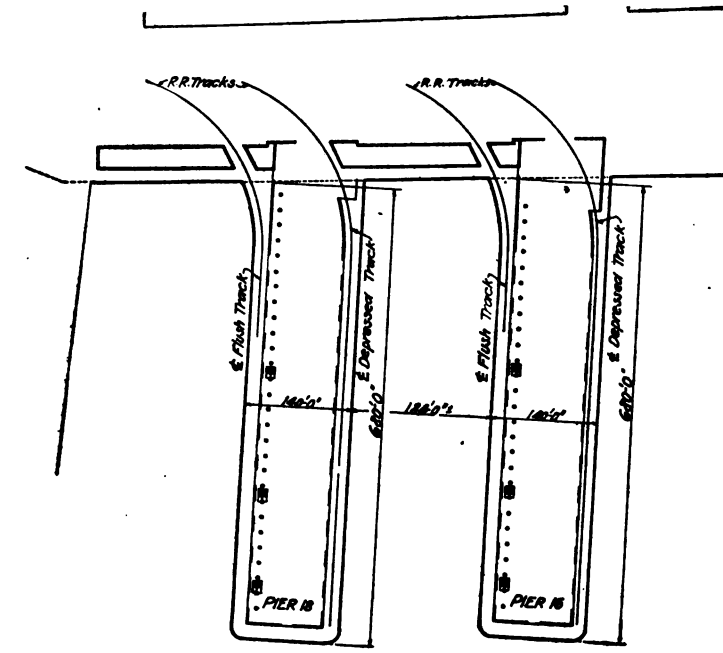
Steel ship characteristics.

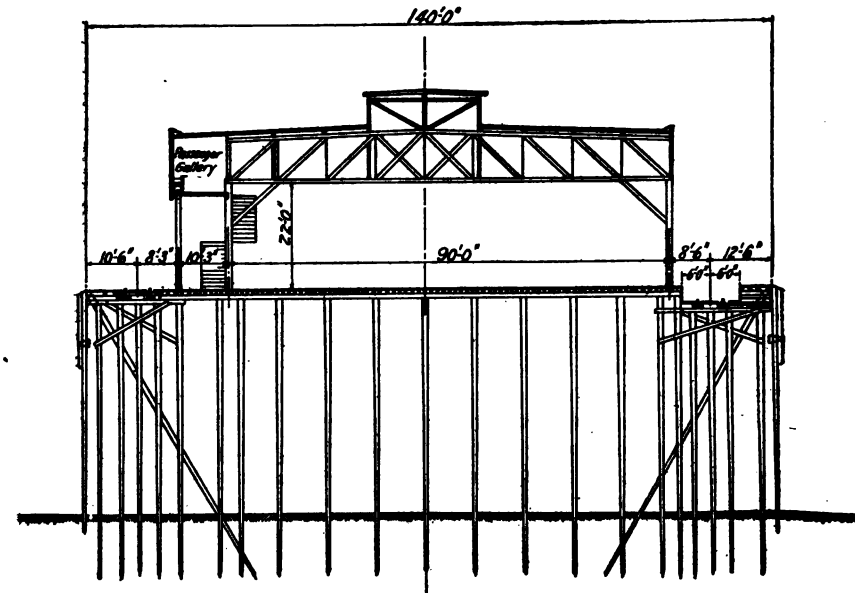
	3,550 dead-weight tons.	12,000 dead-weight tons.
Gross tonnage	2,316	7,888
Net tonnage	1,358	4,960
Indicated horsepower	1,200	3,000
Designed speed, knots	9.5	11.0
	Ft. in.	*Ft. in.*
Length over all	261 0	457 0
Molded breadth	43 2	56 0
Molded depth	26 0	38 0
Load draft	21 0	28 6

42. It will be noted that while the length of the 3,550-ton ship is 261 feet, and that of the 12,000-ton ship 457 feet, the net tonnage of the smaller vessel is 1,358, whereas that of the larger vessel is 4,960. In other words, while the length of the larger ship is only 75 per cent greater than that of the smaller, the net tonnage is practically three times as great, and when it is considered that the actual cargo tonnage represented in the case of the larger ship is practically 10,000, and that space must be provided on the pier for the handling of 10,000 tons in and 10,000 tons out, it is readily understood that great width is required. This in turn demands the use of mechanical devices in order that the enormous area may be economically available. We will, however, touch upon this point again.

43. *Materials of construction.*—Piers or wharves may be entirely of timber construction, with timber piles supporting the necessary caps, joists and flooring, with wood frame superstructure; or they may be entirely of concrete, with reinforced concrete decks and steel or concrete superstructure, or again, the pier may be a tongue of land dredged on both sides and surrounded by a masonry sea wall, with timber substructure and steel or concrete superstructure, or, in fact, any combination of the above may be used, as will be further indicated by the description of actual piers. In deciding the type of construction to be adopted, its expected life must be taken into consideration. If fairly permanent accommodations are required, it should be borne in mind that untreated timbers exposed to alternate wetting and drying will scarcely, in any part of the United States, last over four or five years, and in some climates considerably less. Timber pile work, to be fairly permanent, therefore, must stop at the permanent wet line which is in general about 1 foot to 18 inches above mean low tide. If under such conditions the structure is built in fresh water, the timber work should last indefinitely. If, on the other hand, it is in salt water, the ravages of marine borers must be taken into consideration. If the teredo, the xylotrya, the limnoria, or other marine pest of similar nature is locally prevalent, all timber work must be protected either by careful creosoting, in which event it should have a life of 18 to 20 years, or by other means which will exclude the marine borers from the timber; otherwise, concrete piles, concrete piers, or other material not subject to such attack must be used.

44. *Examples of pier construction.*—Figure 13 shows the plan and typical cross section of piers 16 and 18 at San Francisco, Calif. This is an example of timber construction. The deck is of timber sup-

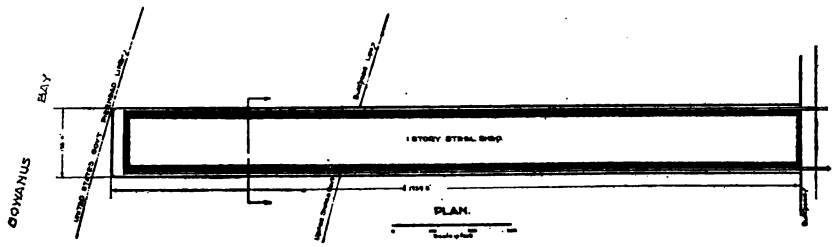




TYPICAL CROSS SECTION

Figure 13.

ported by standard timber piles, while the house or transit shed is also of wood. Note the flush railway tracks on one side of the pier and the depressed tracks on the other side. The latter are provided for bringing the decks of railway cars flush with the surface of the wharf, thus facilitating the loading and unloading of box cars or flats. The length of 680 feet is more than sufficient to accommodate



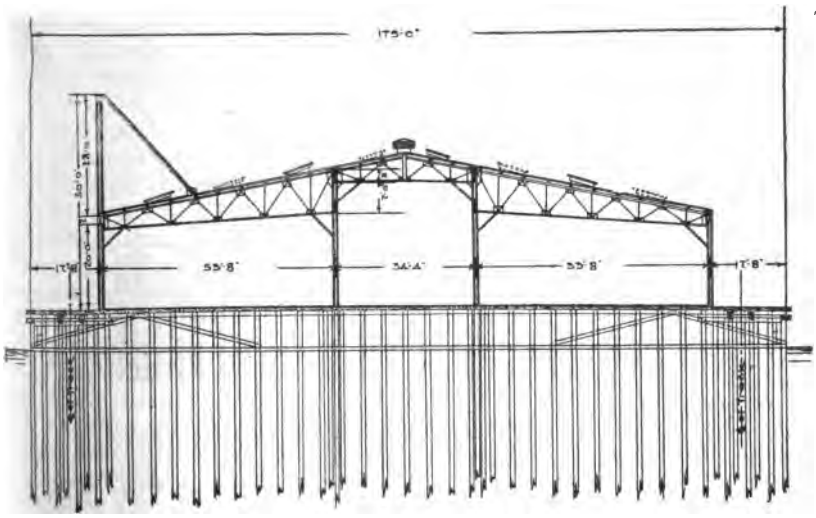
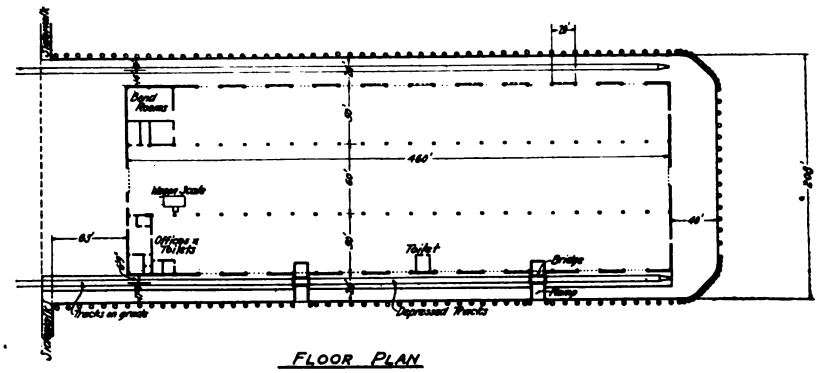


Figure 14.

two ships of the 3,550 dead-weight ton type described in paragraph 16, and is also much more than sufficient to accommodate the 12,000 dead-weight ton ship. Its width is, however, insufficient to take care of the in-and-out cargo for a ship of the latter description, handling on one side only and, with a ship of this character on each side, unloading and loading operations would necessarily be much delayed.

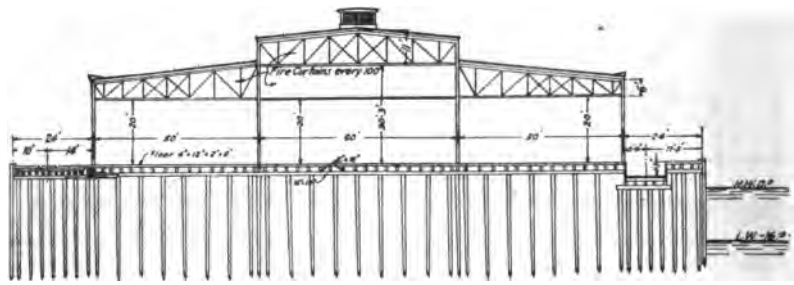
45. Figure 14 shows the plan and typical cross section of the Thirty-fifth Street Pier at South Brooklyn, N. Y. In this case the

substructure is of timber pile and frame construction with a concrete and asphalt floor. The superstructure is of steel. The piles of such a pier, if untreated will, as before remarked, decay and renewals will be required. If creosoted materials are used, the life of the piles should be 18 to 20 years. Note the extended column and bracing construction at the left side of the building. This supports at its top a continuous girder, the structure as a whole being called a cargo mast. As hereafter described, the top longitudinal girder is used



FLOOR PLAN

Scale in feet



TYPICAL CROSS SECTION

Scale in feet

Figure 15.

for the connection of a Burton fall, which is operated by a hoisting engine for cargo transfer between ship and shed. This pier is 1,739.8 feet long, and is thus capable of berthing several large ships on each side, but when it is considered that fully 30 per cent of the floor space must be kept free for trucking, that cargo must be assembled in advance in classified piles, if even fair expedition is to be made with shiploading, and that space must also be provided for classified piles of incoming cargo, it must be apparent that it would be uneconomical to attempt to load and unload many ships at the same time with so little available floor space. It should also be noted that although the railroad tracks running on either side of the transit shed are one-third of a mile long, they are stub ended, single tracks,

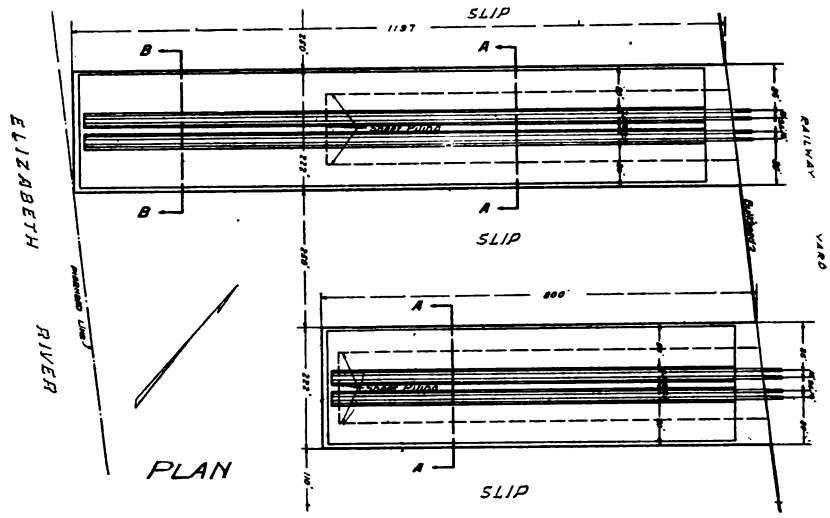
and it would therefore be necessary to draw a train the entire length of the pier at one time in order to keep the outer end of the pier supplied. With the tracks entirely full of cars it would be practically impossible to place the cars in the trains so that the goods intended for the vessel lying at any one berth would be opposite the ship.

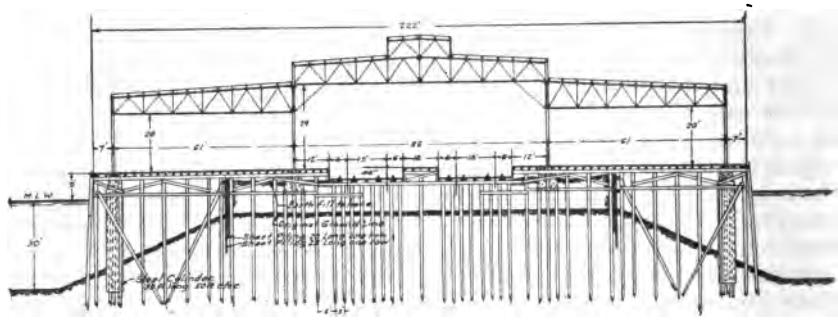
46. Figure 15 shows plan and cross section of a pier with timber substructure and steel superstructure built by the Oregon-Washington Railway & Navigation Co. at Seattle, Wash. In this case also provision has been made for standard-gauge tracks, depressed on one side and flush on the other. Note also that the tidal range is 16 feet, and that, in consequence, inclined ramps have been provided upon that side of the shed which has the depressed railway track. This pier provides a berth on each side for a ship of length closely corresponding to the 12,000 dead-weight ton steel vessel described in paragraph 41. The provision of floor area for the transit shed is much more liberal than in the case just cited, and we will find as we proceed that the Pacific coast practice is in general, at the present time, much more liberal and progressive than that on the Atlantic and Gulf coasts. Even so, with a ship of 10,000 cargo tons on each side engaged simultaneously in loading and unloading operations, the shed capacity would be insufficient to promote the greatest dispatch. The headroom from floor to bottom cord of roof truss is 20 feet, which will allow high stacking of freight, but such stacking introduces an added expense that should not be incurred unless absolutely necessary.

47. Figure 16 shows plan and cross sections of the Norfolk & Western Railway's piers at Lambert Point, Norfolk, Va. Here the width of pier and transit shed is even greater than that shown by figure 15. In this case the construction details are somewhat different, in that the columns supporting the roof trusses are in turn supported upon cylinder piers which are founded upon groups of wooden piles. These groups of piles are surrounded by a steel cylinder filled with concrete. While the floor of the pier is supported by timber pile construction, it was found advisable, in order to secure the proper clearance, to place the longitudinal columns 50 feet apart, thus forming heavy concentrated loads, hence the groups of piles. The steel cylinder and concrete construction is required to protect the timbers from the ravages of the marine borers. Note that in this case the wharf apron outside the building is only 7 feet wide. Access to the railroad is secured by means of four depressed tracks in the center of the pier. While this arrangement is best, so far as the relationship between car and ship is concerned, it has the disadvantage of cutting the pier in two longitudinally and taking up space for the railroad tracks which would otherwise be available for the storage of cargo. With modern means of mechanical transfer, it would have been a better arrangement to bring the railway tracks flush with the floor. While the building in this case is considerably wider than that shown in figure 15, the available floor space for the Seattle pier is much greater. Section B–B shows open construction throughout. Section A–A, taken farther inshore, illustrates a method of holding solid fill down the middle of the pier. Sheet pile bulkheads held in place by pile and timber bracing are provided to retain this fill.

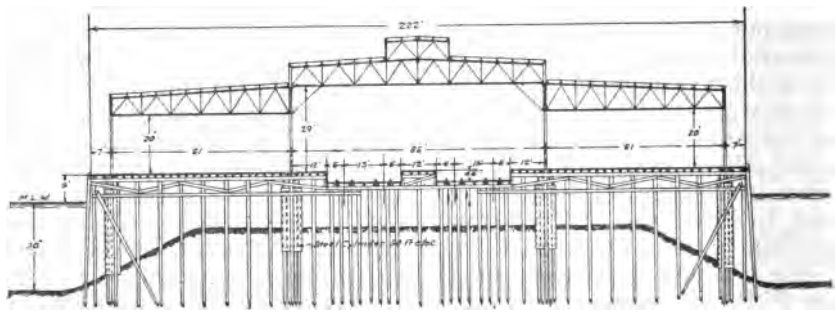
48. Figure 17 shows the Kenilworth Street Pier, No. 30–S, at Philadelphia, Pa. This is one of the older piers, and it is doubtful

whether the Philadelphia port authority would repeat its design at the present time. It is interesting principally as showing another





SECTION A-A



SECTION B-B

Figure 16.

type of construction. The water in the Delaware River at Philadelphia is entirely fresh and creosoted piles are unnecessary. As will

be seen from the cross section, the piles were cut off just above the low-water line and capped with reinforced concrete. The cross walls of reinforced concrete are 20 feet center to center, supported

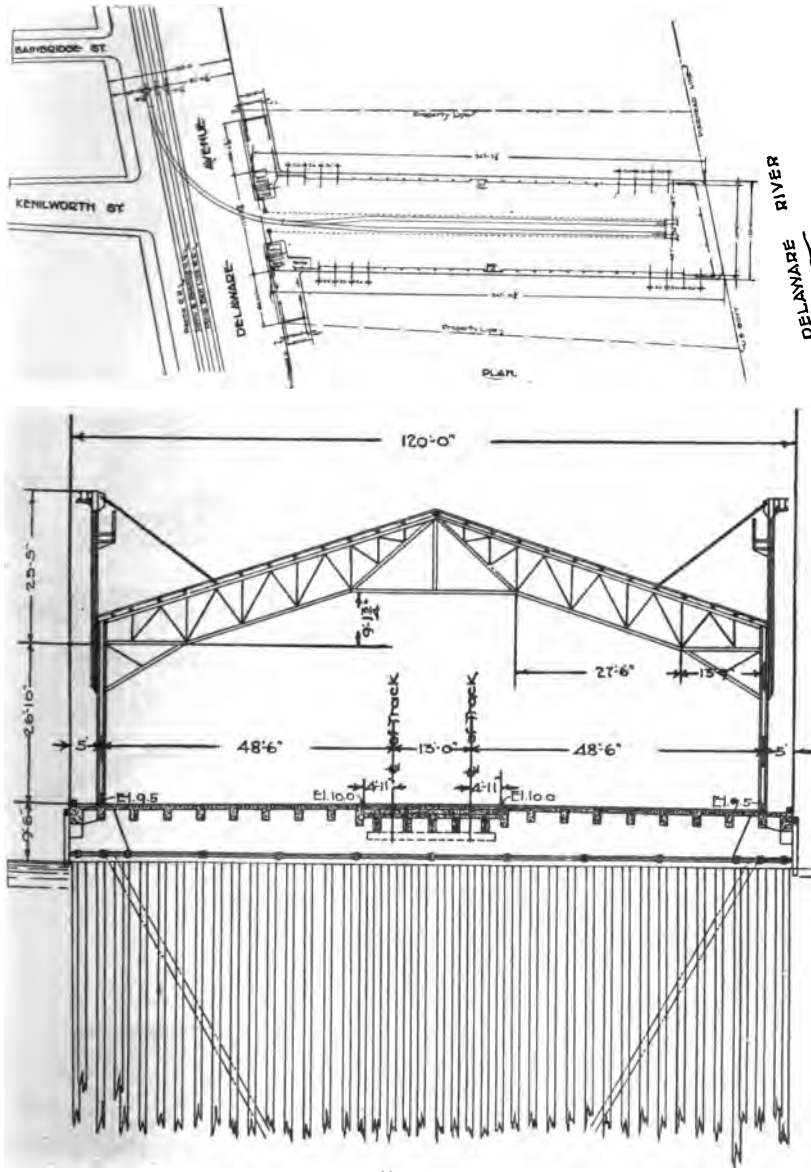
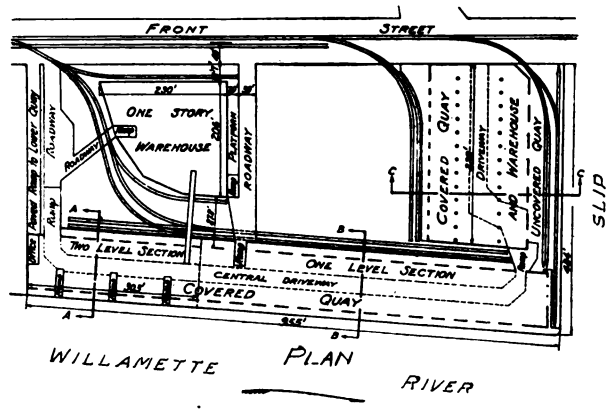
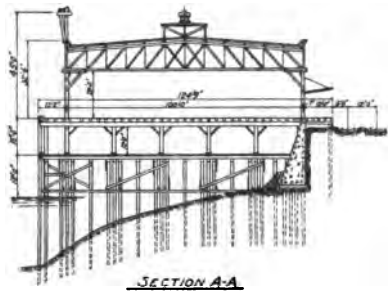


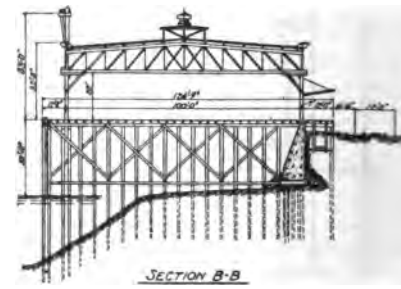
Figure 17.

each by two rows of standard piles driven transversely to the axis of the wharf. These walls carry the reinforced concrete beam and slab construction. While this pier has two railway tracks, these are

flush with the main floor. Cargo masts for Burton falls are supplied for both sides of the pier.







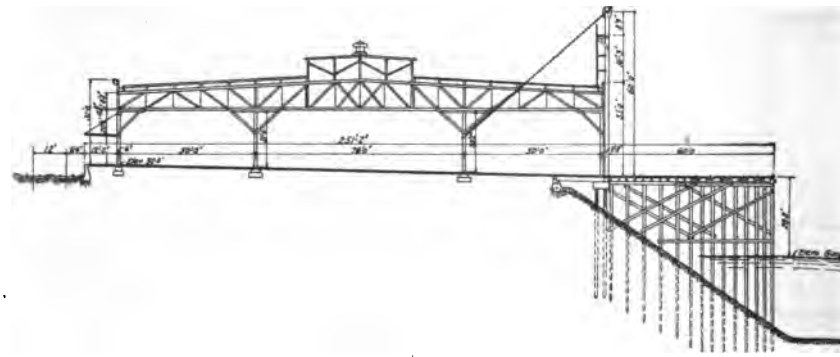
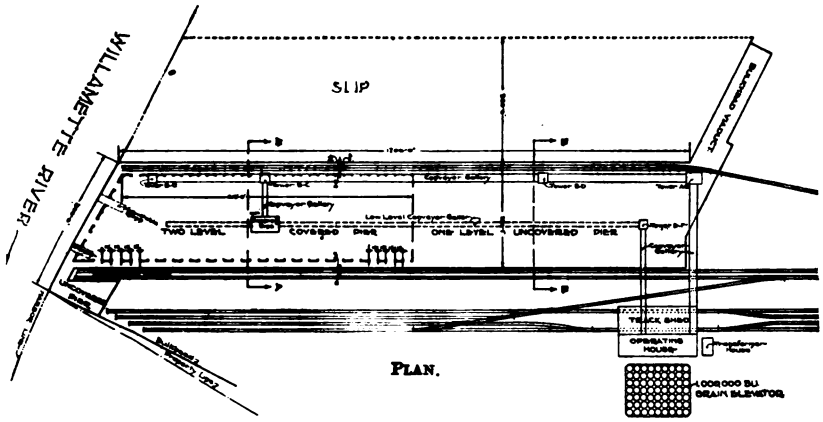
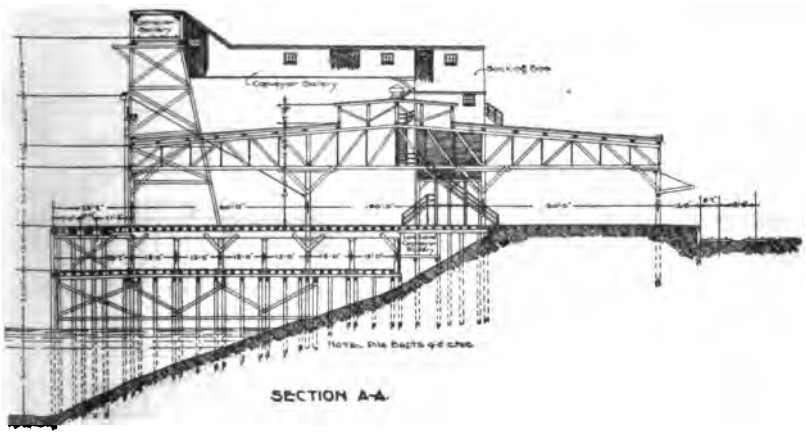


Figure 18.

49. Figure 18 shows details of Public Dock No. 1 at Portland, Oreg. The conditions here are unusual in that the Willamette River at Portland has an extreme flood range of about 30 feet, and for this reason the main deck of the wharf has been placed 28 feet and 10


WILLAMETTE RIVER
SLIP
TWO LEVEL
COVERED PIER
ONE LEVEL
UNCOVERED PIER
TRUCK SHED
OPERATING HOUSE
PLAN.


SECTION A-A.

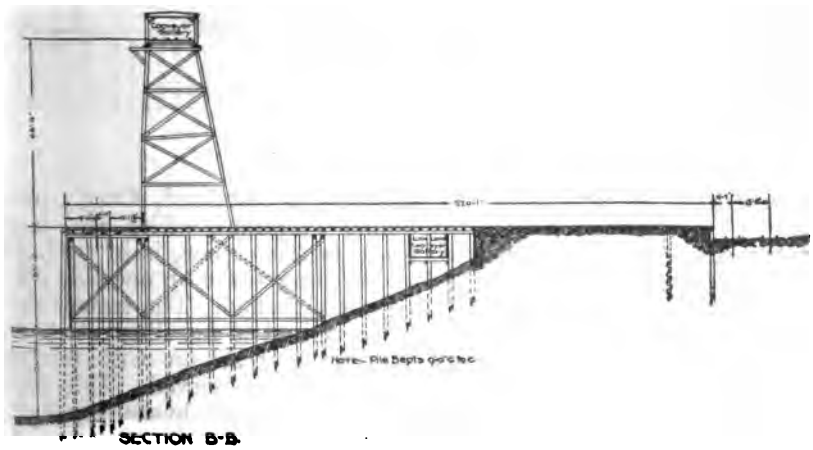

SECTION B-B.

Figure 19.

inches above zero gauge at the uncovered pier and 32 feet 10 inches and 32 feet 6 inches above zero gauge at the covered quay. The fact that this is quay and not pier construction is well worthy of attention. Although a ship can lie at but one side, the shed has a width in one case of 100 feet and in the other of 176 feet. With the exception of the concrete gravity retaining wall at the back of the shed, this construction is of timber. Section A–A shows a double-deck arrangement, but the lower deck can be used only when extreme flood conditions do not prevail. Note further the excellent arrangement of railway tracks.

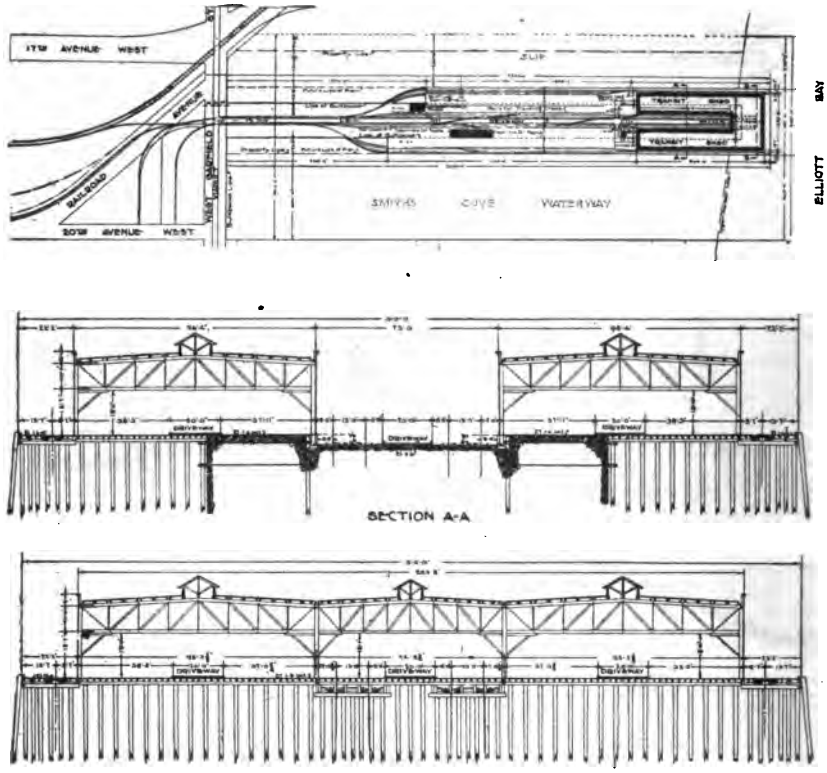
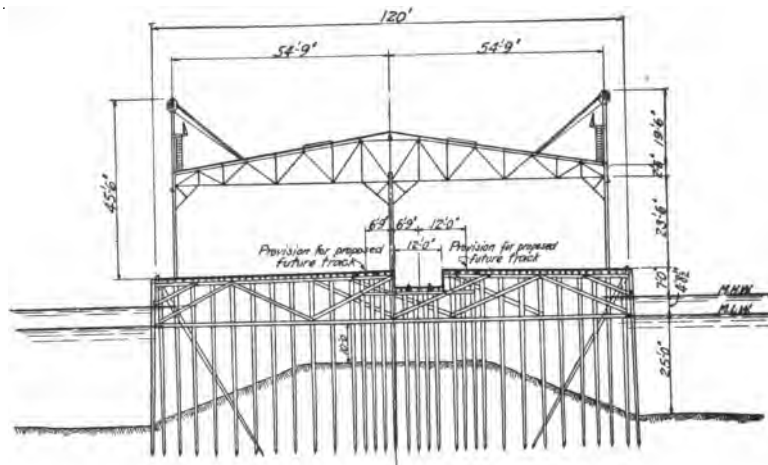


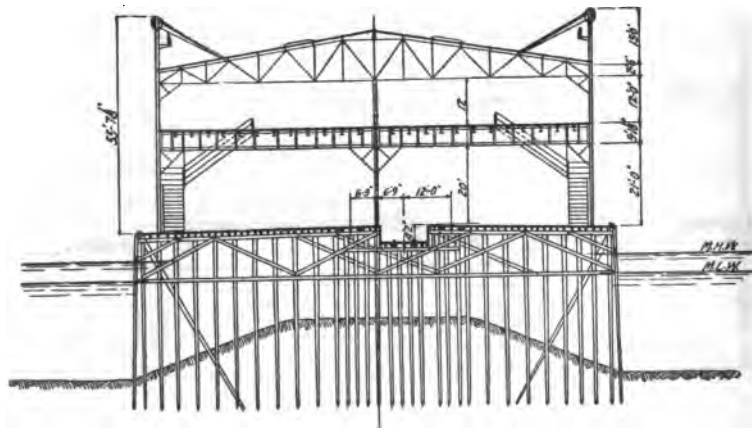
Figure 20.

50. Figure 19 is another illustration of Portland, Oreg., practice. It shows Pier No. 1, St. Johns Terminal, which also is of timber construction and which, while called a pier, is in reality a wharf or quay, providing as it does berthing space on one side only. Here, too, part of the structure is double-decked. The transit shed area is more liberal than that of any terminal so far illustrated, and the same excellent arrangement of railroad trackage with relation to the water front as shown by figure 18 is preserved. This illustration is also valuable in that it shows a 1,000,000-bushel grain elevator, with the closed conveyor gallery for the belts arranged to transfer grain mechanically from elevator to ship.

51. Figure 20 shows Pier A at Smith Cove, Seattle, Wash., and is illustrative of the most recent Pacific coast construction. It will



CROSS SECTION OF ONE STORY PORTION



CROSS SECTION OF TWO STORY PORTION

Figure 22.

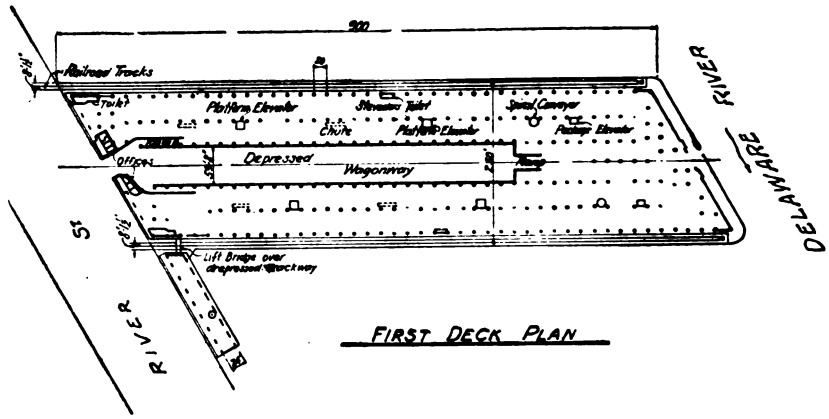
be noted that this pier has an over-all width of 310 feet. Driveways are provided both down the center of the pier and in the center of the transit shed of each dock face. Single railroad tracks are provided on each dock face just outside the transit sheds, four railway tracks down the center of the pier serving each transit shed at its rear. This is another case of timber construction, and combines open construction for the apron on each side of the pier with solid fill, confined behind sheet-pile bulkheads, for the center portion of the pier.

52. Figure 21 shows the Ocean Steamship Co.'s terminal at Savannah, Ga. While these are called piers, they are in reality quays or wharves. The construction is a combination of timber, reinforced concrete, and steel. While the shedded area is large, available floor space under cover is comparatively small. The slip is doubtless wide enough for the coastwise steamers for which it was designed, but it is too narrow for its length if used for loading and unloading large vessels in the export and import trade. Vessels of 10,000 tons deadweight could lie opposite each other in this slip, but were such vessels placed at its entrance it would be difficult, if not impossible, for others to pass them, and quite impossible if they should have lighters alongside.

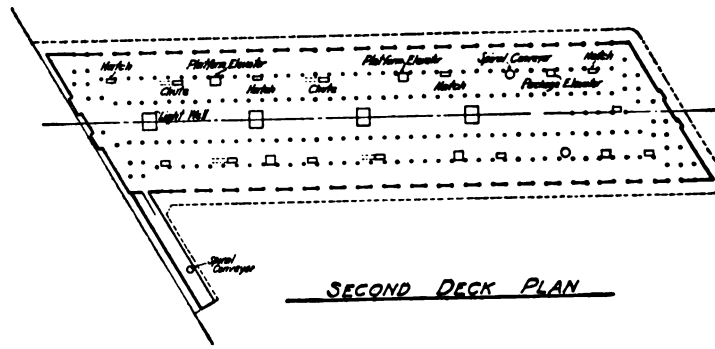
53. In order to increase the available floor area, resort is frequently had to the construction of two-story transit sheds. Figure 22 shows a combination of one and two story construction at Providence, R. I. The outer end of the building is one story high and the inner end two stories. The substructure is of timber and the superstructure of steel. While the pier is over 600 feet long, it can scarcely be said to be so designed as to be capable of turning a large ship around with the utmost dispatch. Only 400 feet of the length is provided with transit shed, and the width of this shed is not sufficient to accommodate cargo for two ships at the same time.

54. Figure 23 shows the McKean Street Pier, No. 78–S, at Philadelphia, designed by the department of wharves, docks, and ferries. It combines open aprons with solid fill behind bulkheads. Timber piles are used to the permanent wet line, with reinforced concrete for the aprons above low water. Concrete pedestals supported by piles form the foundations of interior columns of the two-story steel superstructure. In this case the railroad tracks on the two faces of the pier are depressed, as also is the driveway, 59 feet, 8 inches wide, down the middle of the first floor. This latter is intended to provide space for trucks to back up at either side, while leaving a sufficient width between for other trucks to pass. While the overall width of the pier in this case is 250 feet, a considerable proportion of the first floor is taken up by the central driveway. Nevertheless, the area available for cargo is vastly greater than that of the pier shown by figure 14. Note the provision, as indicated on the first and second dock plans, for platform and package elevator, spiral conveyor chutes, etc.

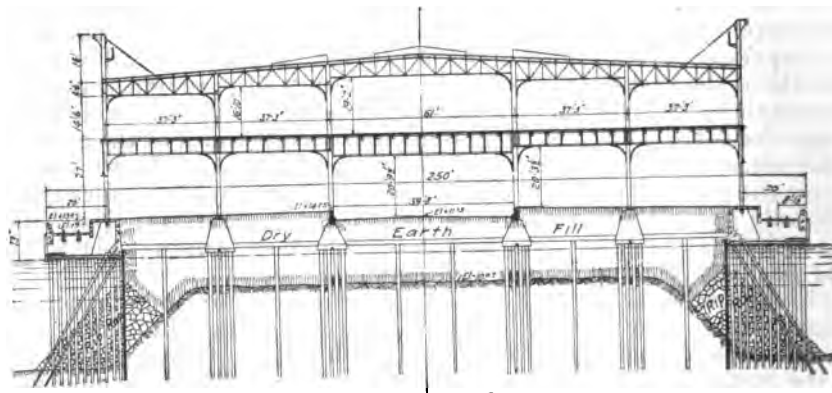
55. Figure 24 is an excellent example of an all reinforced concrete construction. The Halifax port authority has designed the supports in this case of concrete. They are 24-inch square precast piles, and if the materials and workmanship are good, there should be no question as to the permanency of the structure.



FIRST DECK PLAN



SECOND DECK PLAN



TYPICAL CROSS SECTION

Figure 23.

56. Figure 25 shows the Baltimore & Ohio Railway Co.'s pier at Locust Point, Baltimore, Md., which has a pile substructure supporting a timber platform just below the permanent wet line, above

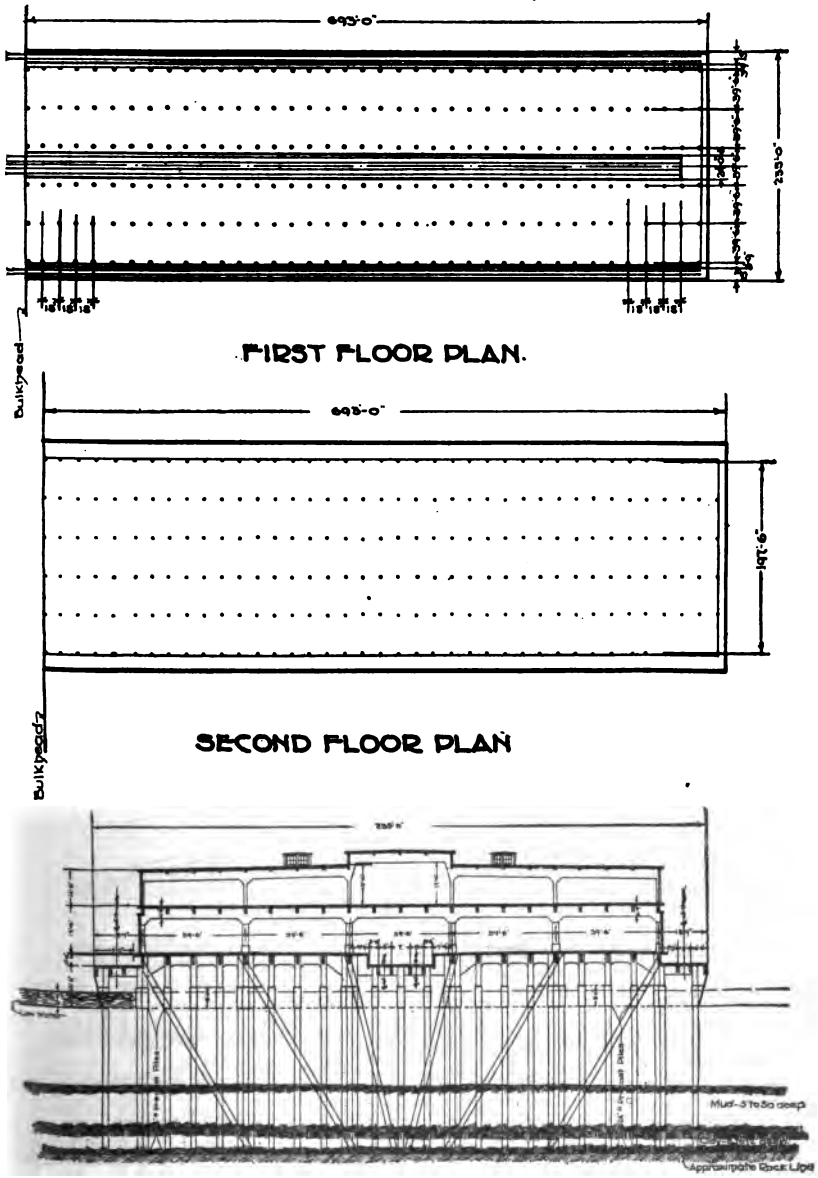
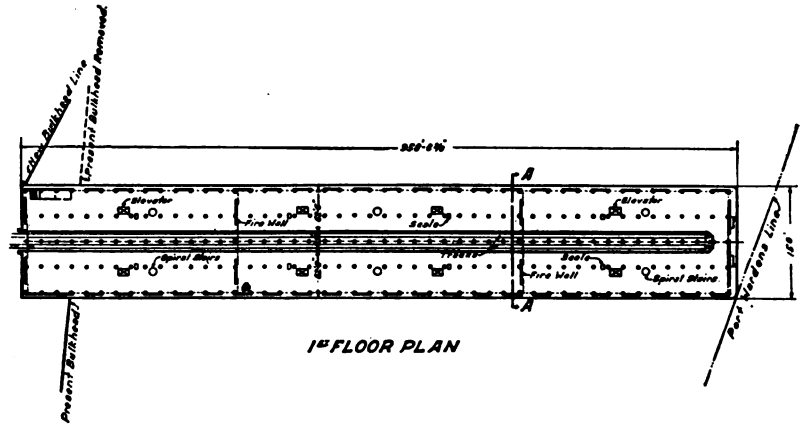
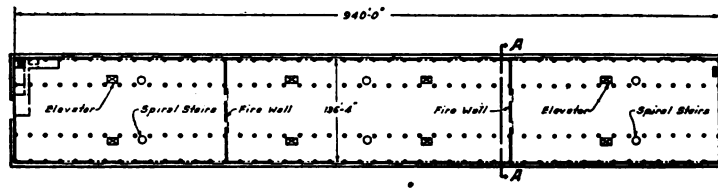


Figure 24.

which concrete walls confine solid fill, and concrete piers support the interior columns of a two-story steel shed.

57. Figure 26 illustrates two modern structures at Philadelphia. They are Southwark piers Nos. 38 and 40–SW. Both have timber


Present Bulkhead Line
Proposed Bulkhead Removed
356'-6"
A
Elevator
Fire Wall
Scale
Spiral Stairs
Present Bulkhead
Port Jefferson Line
1st FLOOR PLAN


940'-0"
A
Elevator
Spiral Stairs
Fire Wall
156'-4"
2nd FLOOR PLAN

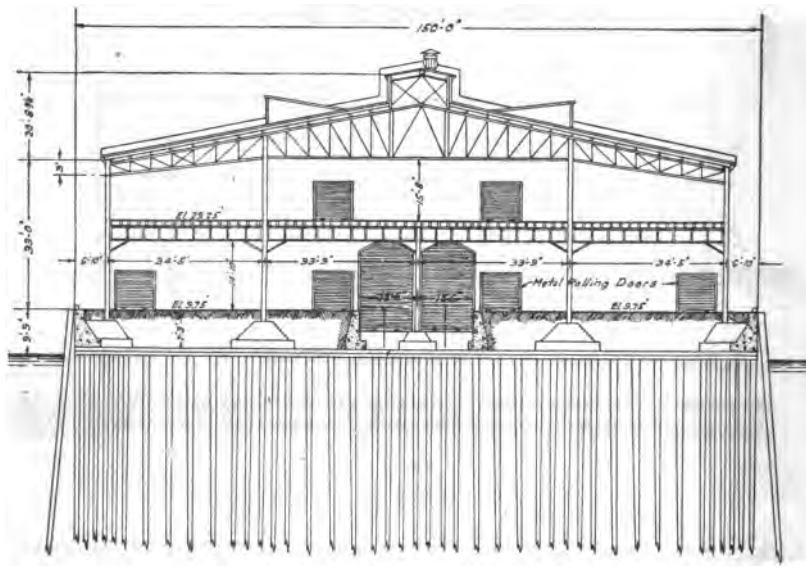
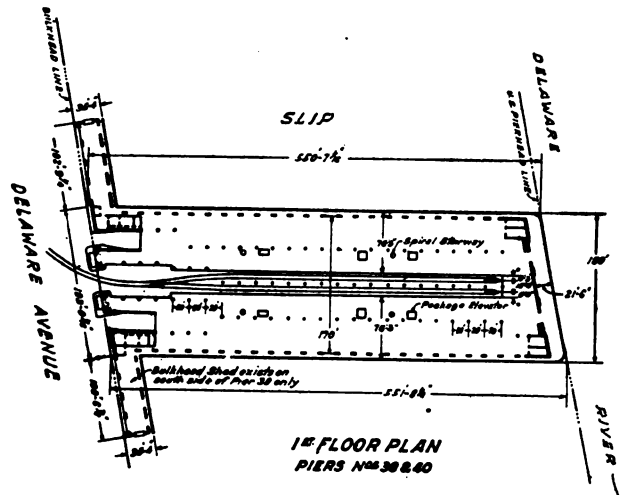
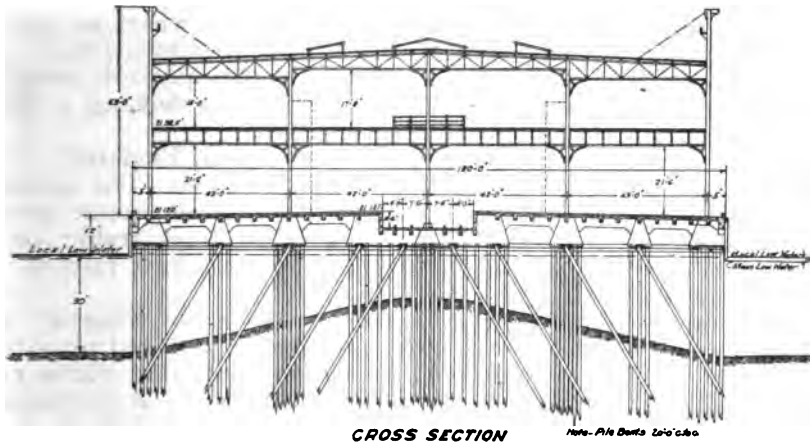

150'-0"
Metal Rolling Doors
SECTION A-A

Figure 25.


SLIP
DELAWARE AVENUE
DELAWARE
RIVER
Bulkhead Shed exists on south side of Pier 38 only
1st FLOOR PLAN
PIERS Nos 38 & 40


CROSS SECTION
PIER NO. 38

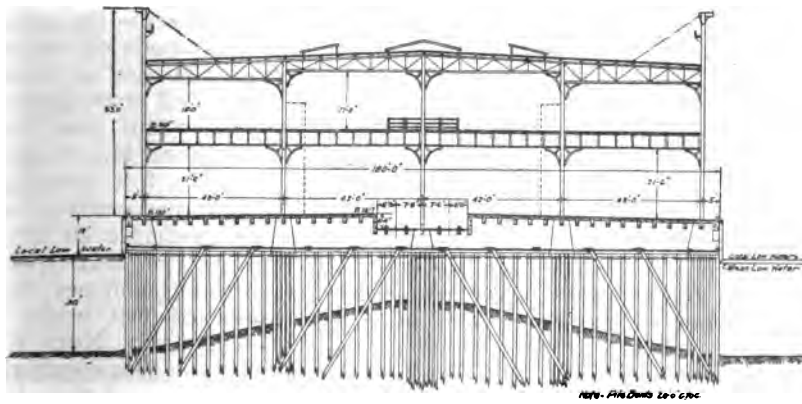

CROSS SECTION
PIER NO. 40

Figure 26.

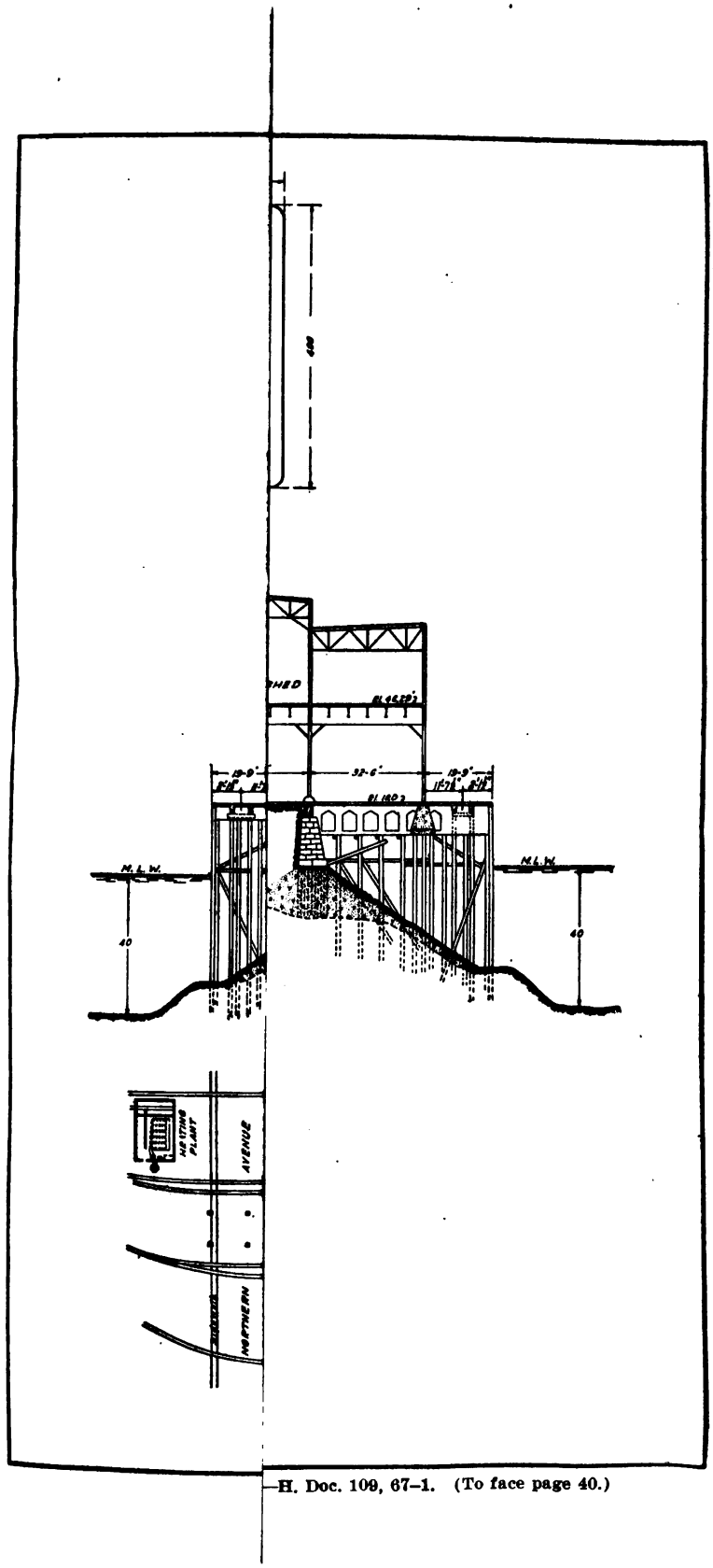
pile supports below the permanent wet line, but for pier 38 a concrete pier construction has been used to support the reinforced concrete first floor; whereas for pier No. 40 continuous concrete cross walls have been adopted. The two-story shed in each case is of steel.

58. Figure 27 shows Commonwealth Pier No. 5 at Boston, Mass., constructed by the State. While this is called a pier, it will be noted that it is 400 feet wide, and as each side is served by its own railway, it more nearly approaches quay construction. It has open aprons on both sides, with a solid fill retained behind gravity walls for the entire central portion of the structure. The transit shed has two stories, and although the ground floor is cut in two by the depressed tracks which serve each side, these depressions are furnished with bridges so that the middle area is quite available for freight in transit. Here we have something approximating the necessary space to accommodate the in-an-out cargo of large transoceanic ships.

59. Figure 28 shows the Delaware, Lackawanna & Western Railroad pier No. 9, at Hoboken, N. J. This also, being provided with a ship berth at one side only, is more properly a wharf or quay. The relationship between ship, transit shed, and rails is ideal, but the width of the shed is scarcely sufficient for the quickest possible dispatch. The illustration is principally valuable as showing a form of construction.

60. Figure 29 shows a typical quay at Liverpool, England. The quay wall is a shell of concrete facing rock excavation. The greater part of the structure is old fashioned, and there is not proper access for the railway. The quay shed shown is for truck traffic only. Note the thirty hundredweight hydraulic crane which moves on tracks along the roof.

61. Figure 30 shows the plan and cross sections of some of the typical piers of the New York dock department's proposed terminal now under way at Staten Island. It will be noted that while two of the piers are 209 feet wide, with two-story sheds and provisions for modern mechanical handling equipment, most of the piers, although considerably over 1,000 feet long, are only 125 feet wide with one-story sheds, and there is inadequate provision for railroad connection. These piers are supposed to provide berths on either side for large ships, but even should ships be accommodated on one side only, with the other reserved for lighterage, the area available for cargo will still be insufficient and, with the best management possible, unnecessary expense will result. Compare this pier with the construction shown by figure 12, Dock No. 9, at Manchester, England. Practically the entire length of Dock No. 9 is provided with four-story transit sheds 110 feet wide, or approximately 400 square feet of shedded area per foot of quay. Furthermore, to prove that Dock No. 9 has been a successful unit of the Manchester terminal, the proposed quay warehouse shown on the upper left-hand corner of the figure will have five floors 134 feet wide, or about 626 square feet of shedded area per foot of quay. Note also in comparison with the New York plan, the trackage area available at the rear of the transit sheds of Dock No. 9 as shown on the plan in figure 12.



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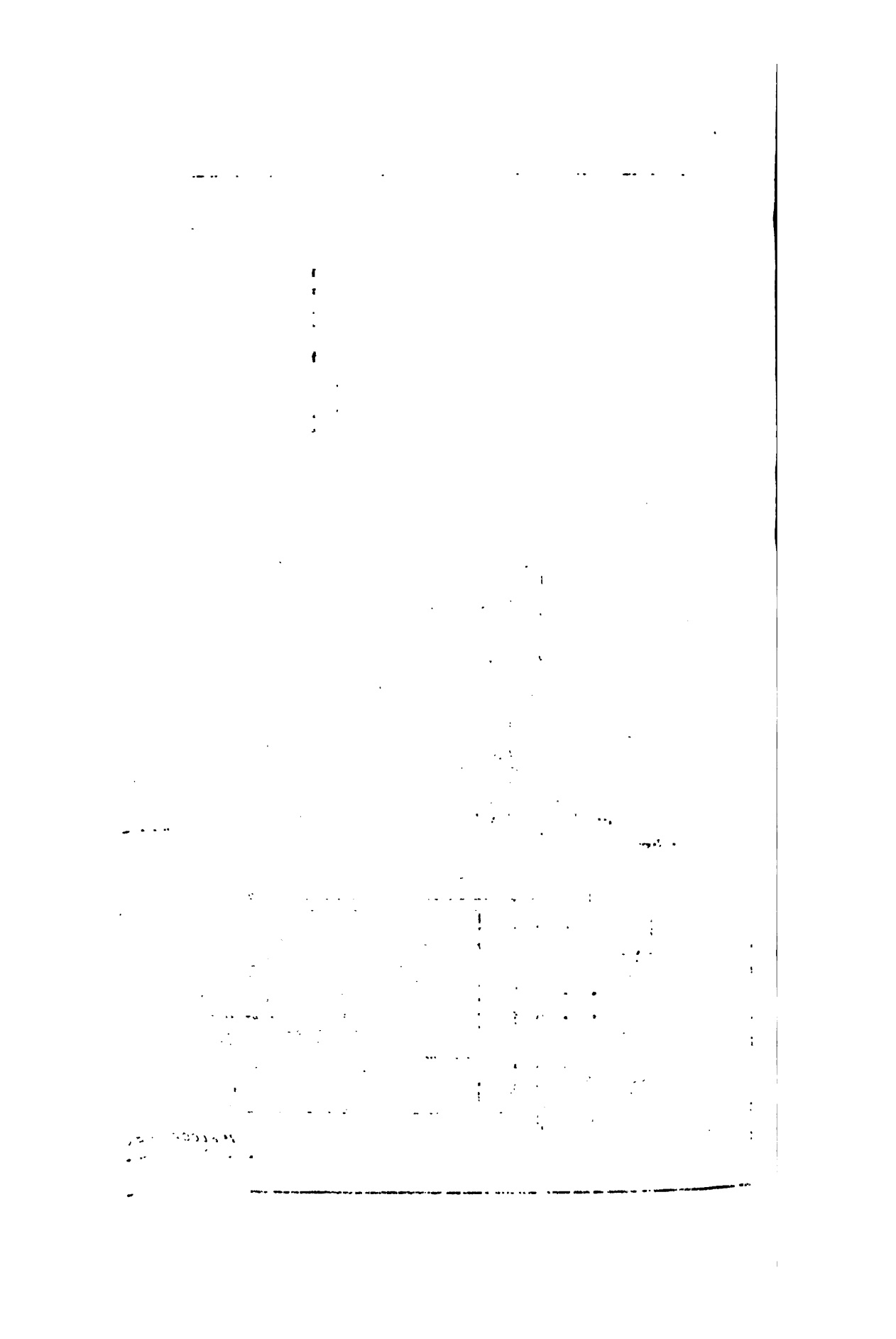
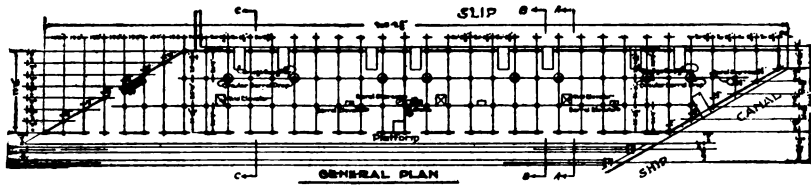
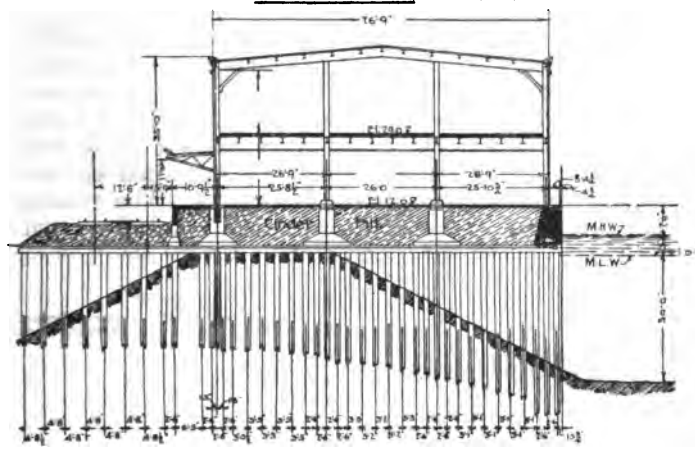
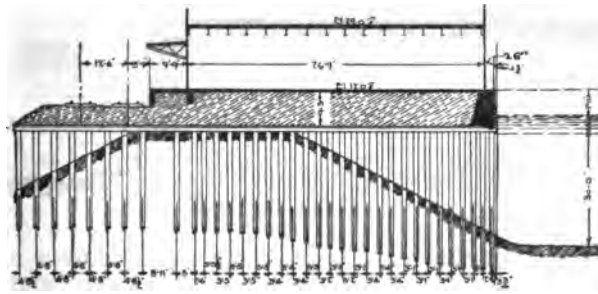


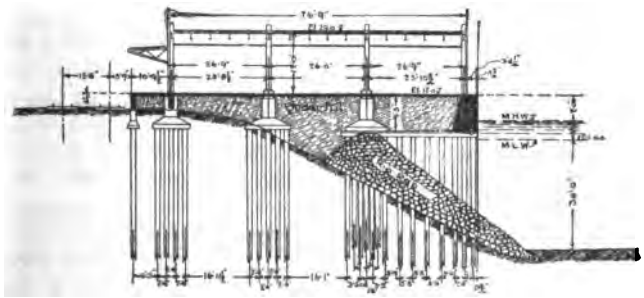




SECTION A-A



SECTION B-B



SECTION C-C

Figure 28.

62. *Quays and wharves.*—We have seen (par. 20) that the word "quay" signifies the area on the water front and parallel thereto, usually bounded by a wall of masonry or composite construction, directly in front of which is sufficient depth for the berthing of vessels; and that the word "wharf" is properly applied to open construction, which also bounds the water front directly parallel to the channel. From the illustrations already given it should now be understood that when a pier becomes so wide as to have on each side its own transit sheds, railway, road connections, etc., and to dictate the use of solid fill, we virtually have two quay systems back to back. We have further seen (par. 16) that the quay system is used almost exclusively in the modern docks or locked basins abroad, and that figure 1, representing the Victoria and Albert Docks at London, is, so far as the Royal Albert Dock and Royal Albert Dock South are concerned, an excellent example of modern terminal construction. It is also a valuable illustration of the quay type. The greatest gain secured from this form of construction is in the relative position of railroad, highway, transit shed, and ship. A very small percentage

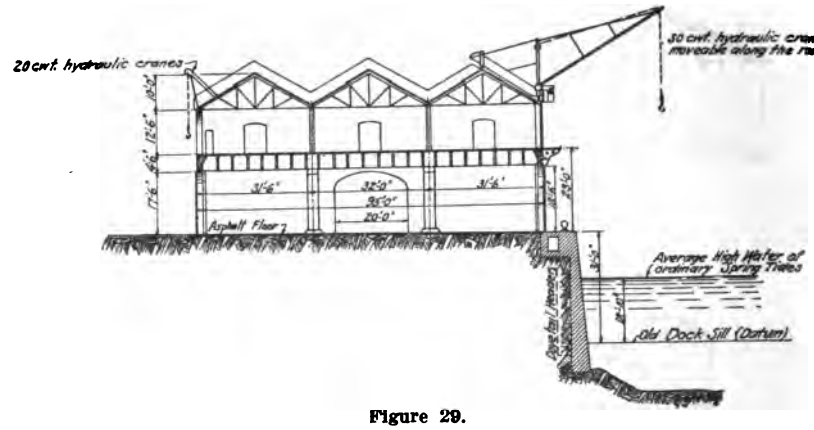
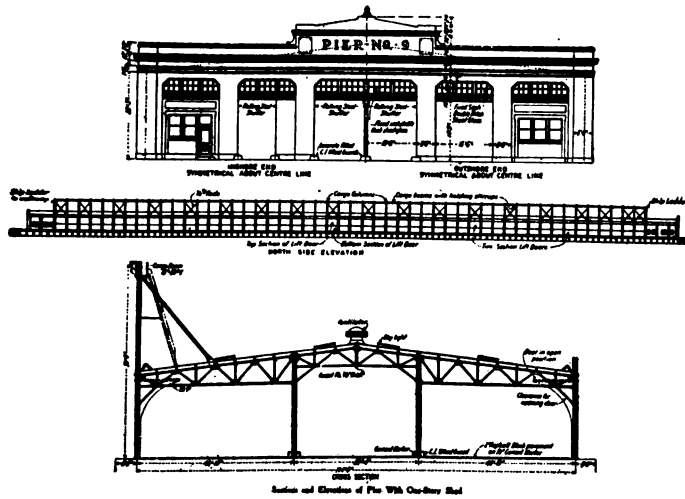
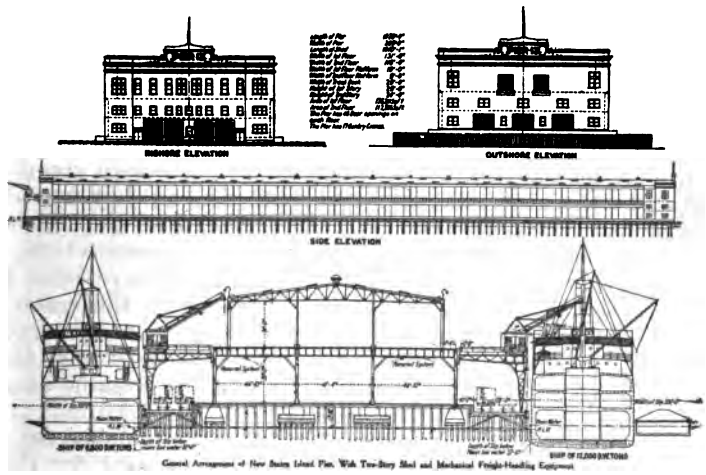

20 cwt. hydraulic cranes
30 cwt. hydraulic cranes movable along the wall
Asphalt Floor
Average High Water of Ordinary Spring Tides
Old Dock Sill (Datum)

Figure 29.

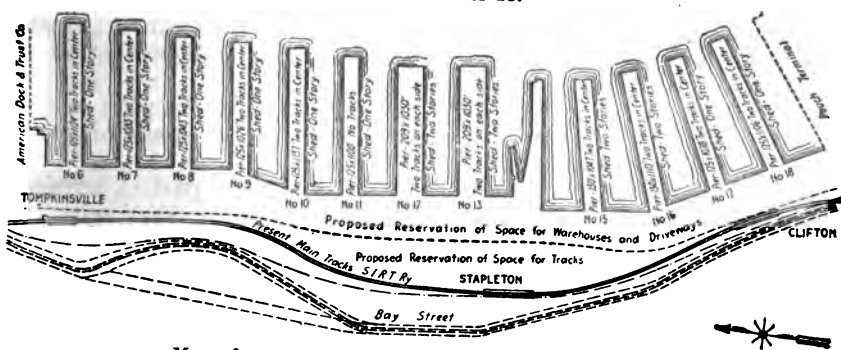
of the package freight requiring shelter which moves over water terminals is transferred direct between car and ship and ship and car, the reason being that imports must first be classified according to commodities and marks of consignees, and exports must be similarly classified, and must also be available for selection by stevedores in the difficult process of stowage. As was remarked in paragraph 40, United States practice has been too much inclined to the construction of narrow piers. A study of the pier illustrations so far given should show the comparative difficulty, where narrow piers are used, of obtaining close contact between roadway and railroad on the one hand and the ship on the other, the lack of adequate cargo space in the transit sheds, and the impossibility of supplying cars fast enough for the quickest turnaround of the ship where such piers are too long and narrow. With the quay system, on the other hand, the movement between ship and railway is the shortest practicable when classification of cargo is taken into consideration, and for the occasional cases where timber, structural steel, or similar materials can be delivered in carload lots in such condition as to allow direct transfer it is a simple matter to provide water-front tracks flush with the



Cross section Pier 9.



Cross section Pier 13.



Map of new terminal development on Staten Island.

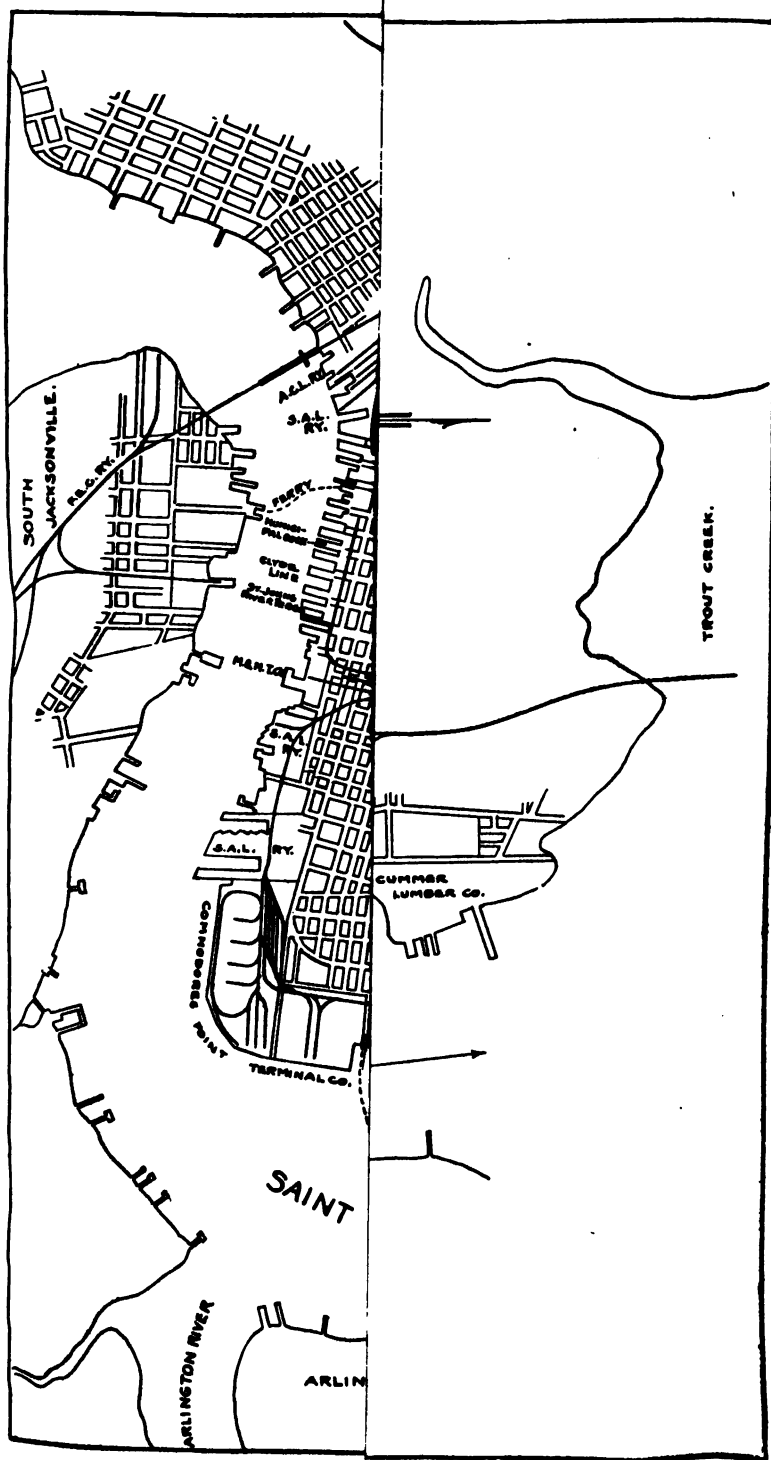
Figure 30.

floor of the wharf, which, when railroad cars are not in use, is thus open to the movement of trucks. With this form of construction the number of tracks at the rear of the transit shed is only limited by the necessity in each particular case. In this connection it should be borne in mind that in the busiest times the number of cars unloaded at an ocean terminal per diem is small in comparison with the number of cars received each day. Records taken over a considerable period are available to show that for one of the trunk-line terminals on the New Jersey shore of the New York Harbor the number of cars unloaded per diem averaged one-tenth of the loaded cars on hand, and the variation from this figure from day to day was not wide. It is therefore apparent that the amount of trackage required per carload actually transferred between rail and water is large.

63. To illustrate further the comparison between pier and quay layouts for port terminal construction, the port of Jacksonville, Fla. (fig. 31), will be considered. The Florida East Coast Railroad bridge, which crosses the St. Johns River just above the city, is the head of ocean navigation. The river at Jacksonville is none too wide for the manipulation of large ships, and had the city of Jacksonville in the early days acquired the entire water front on both sides of the river it would have made available about 10 miles of water front, which, with quay construction, would have constituted an ideal basis for a port layout. The transit sheds would then have been built parallel to the water front and the railway brought in directly behind, with ample space reserved for classification and make-up yards. Furthermore, the largest ships could, under their own steam, have made their berths alongside the quay with ease, as they would have been pointed directly into the current. Instead of this, industrial concerns for whose operation direct water-front connection is not essential, or which could under the quay system have been placed directly behind the railroad, quite as convenient to the water front as with the pier system, have acquired water-front property, and they, the railroads, and individuals have thrust narrow piers into the stream in the uneconomical American fashion. A notable exception to this condition is that of the Commodores Point Terminal (fig. 9), which has taken advantage of a bend in the river to construct an excellent quay wall bounding an area of sufficient extent for the handling of 13 large ships simultaneously. The terminal of the city of Jacksonville is some distance downstream from the heart of the city. The water frontage reserved is only sufficient for a moderate number of piers.

64. The left side of figure 32 shows a general layout plan of perhaps the best construction that may be had upon the remaining city property under the circumstances.

65. *Warehouses.*—Warehouses play an important part in terminal operations. The capacity and type will, of course, vary with the characteristics and quantities of the commodities handled, but in any case they form reservoirs from which to draw, and thus allow the earlier release of both cars and ships. Other things being equal, the warehouse should be as close to the water terminal as practicable. In London and Liverpool, both of which transact an enormous ocean business, a very large percentage of the commodities handled must be



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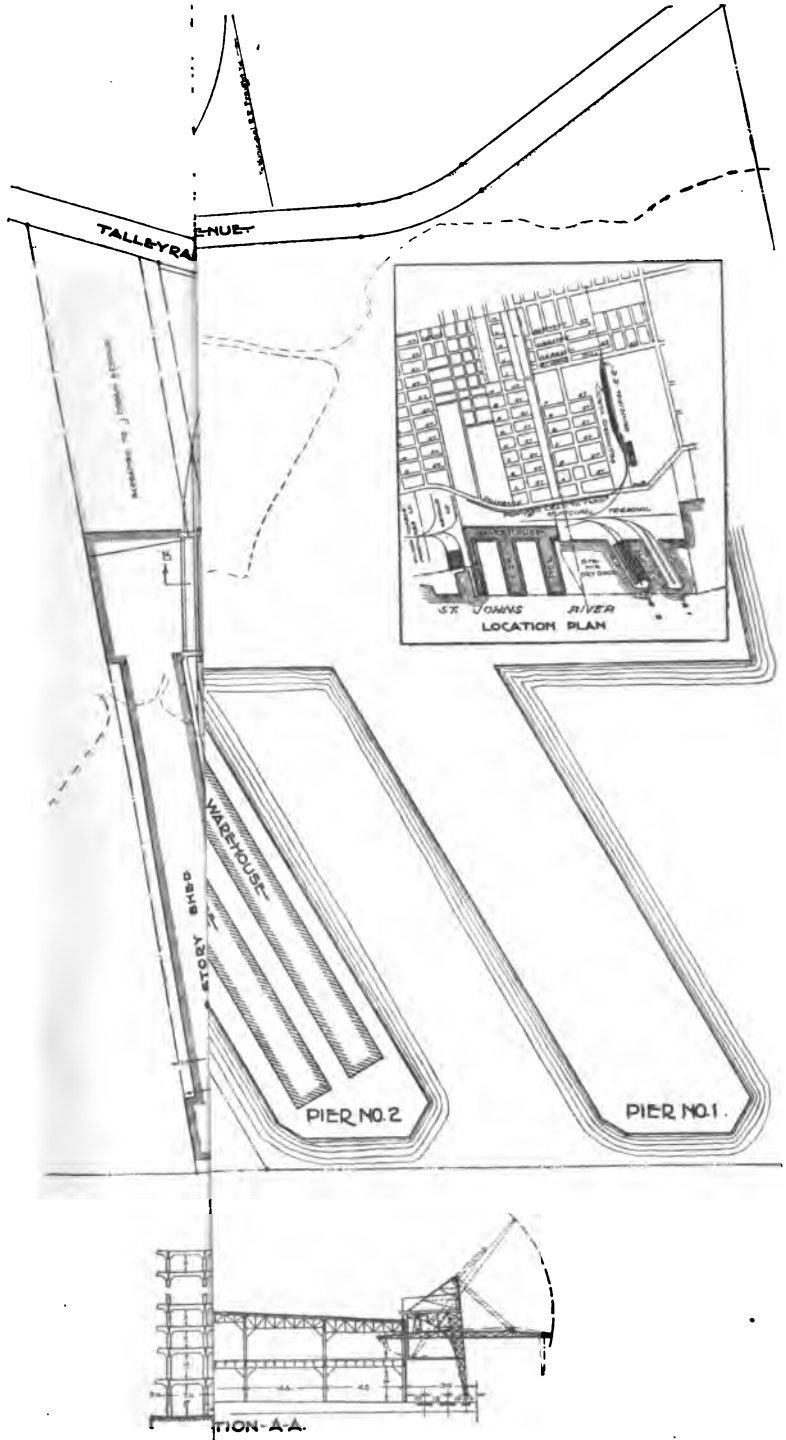

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FIGURE 33-A

FIGURE 34

trucked great distances to storage. One of the best-known warehouse terminals in this country is that at the Bush Docks, in Brooklyn, N. Y. (Figs. 33 and 33–A.) While these warehouses have large capacity, they are situated across a wide and busy street from the narrow piers which they serve, and the distance from the center of the storage system to the center of the docking space is therefore great. Under a quay system the usual distance would be from the face of the quay across the marginal street to the center of the warehouse, and

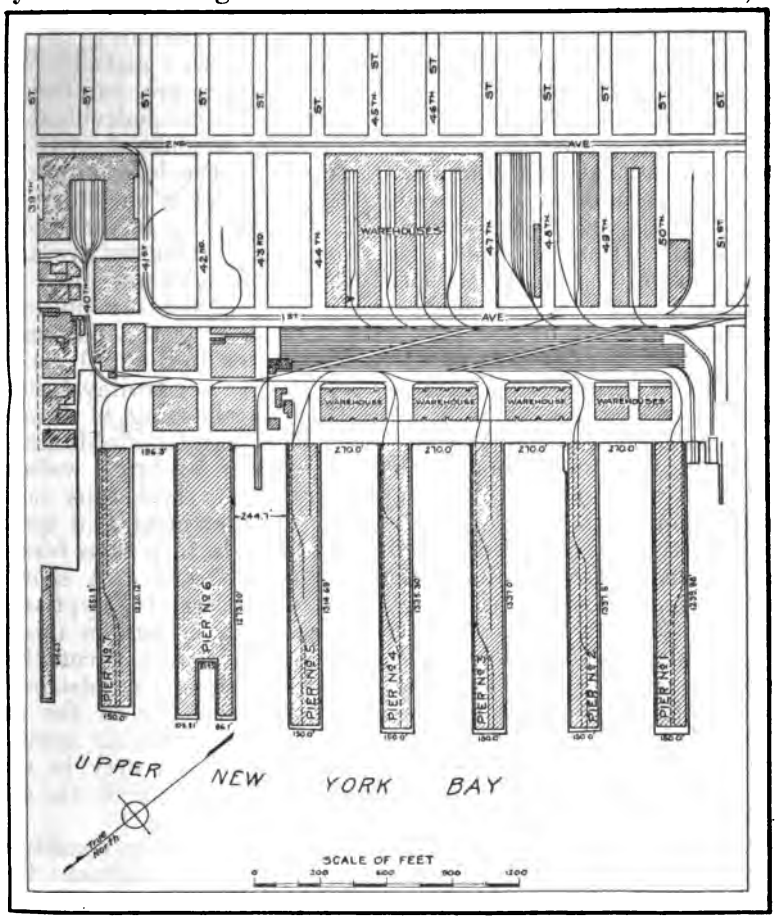


Figure 33.

with favorable foundations the warehouses would better be erected directly above transit sheds, thus reducing the distance from the center of storage to the face of the quay to one-half of the shed width. (Fig. 12.) Such an arrangement would be most economical in terminal operations, and would enable the port authorities to establish rules whereby demurrage cargo could be elevated in the simplest way from the transit area to the warehouse, and there held at the expense of the shipper or consignee. The reinforced-concrete loft type of

building, with the first and second stories used for materials in transit, is particularly adapted, both by arrangement and low fire risk, to terminal warehouse use. In general the design for this purpose will provide considerable height only for the first floor and low height for the remaining stories. Where miscellaneous cargo must be easily accessible, only hand stacking should be practiced, and such stacking above the height to which a man can reach is uneconomical. Additional ceiling height for such warerooms is therefore an unnecessary expense.

66. *Warehouses for special purposes.*—The planning of warehouses for special commodities is, of course, another matter. Where only a few commodities in uniform packages are handled, and where a large variety of marks is not involved, the individual units may be piled by mechanical means to greater heights at small additional expense, and the number of stories in the loft building reduced to a minimum, or, indeed, in special cases a one-story warehouse may be the most satisfactory. As a special instance of this latter construction the New Orleans cotton warehouses are an important example (Fig. 34). Here the cotton bales are piled many tiers high, and a special device has been adapted for pulling individual bales out of the pile, even though near the bottom. In this form of storage it is usual to handle the individual packages by means of an overhead traveling bridge crane or trolley system.

67. An interesting example of cotton warehousing is furnished by the so-called safes of the Trafford Park Estates at Manchester, England. Here each compartment is inclosed by brick walls considerably over 40 feet high, supporting near their tops railway tracks running the entire length of the compartment and spanned by an electrically operated traveling bridge, which in turn furnishes a single track for a trolley hoist. Figures 35 and 35A show the general arrangement of this warehouse, and bales of Egyptian cotton piled 15 tiers high. The trolley handling system in this case is particularly interesting in that by use of small turntables at junction points the trolley hoist can travel along the platform in front of the line of warehouses, turn into any one of the warehouses, or continue along the platform to an overhanging cantilever beam, from which point bales, or other packages, may be transferred to and from railroad cars and a movement made the entire distance from car to storage pile without rehandling.

68. *Railroads.*—We have already seen that a very considerable length of tracks is necessary for a busy water terminal. Ocean carriers should be considered extensions of the trunk-line railways which reach the port and the number of tracks and their arrangement made to fit the local conditions. Every railroad entering the port city should have belt-line connection, switching service, and direct access to every ship's berth in the port. This, in general, means sufficient tracks along the marginal way, either at grade or preferably at the level of the second floor of the transit shed. Where the port does sufficient business to justify the expense of construction and maintenance, there should be an outer belt connecting the main yards and main lines of all railroads. The ports of New Orleans and San Francisco are administered by the State authorities, and at each of these cities the belt road is publicly owned

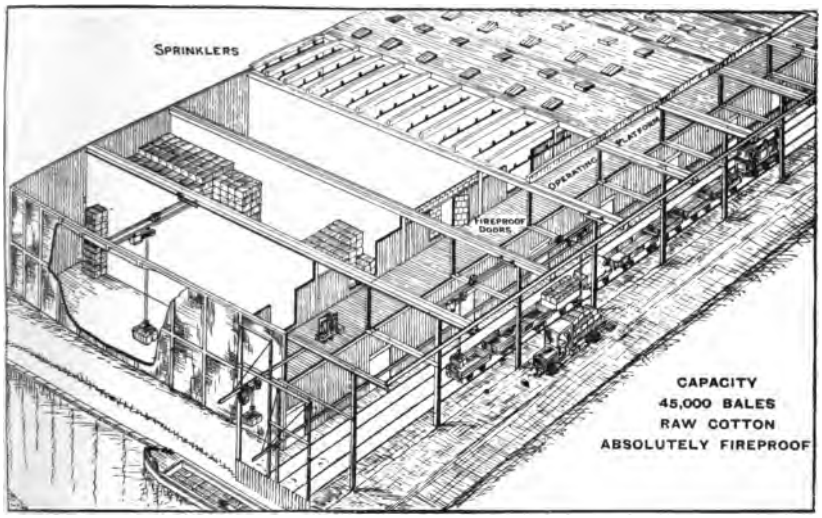
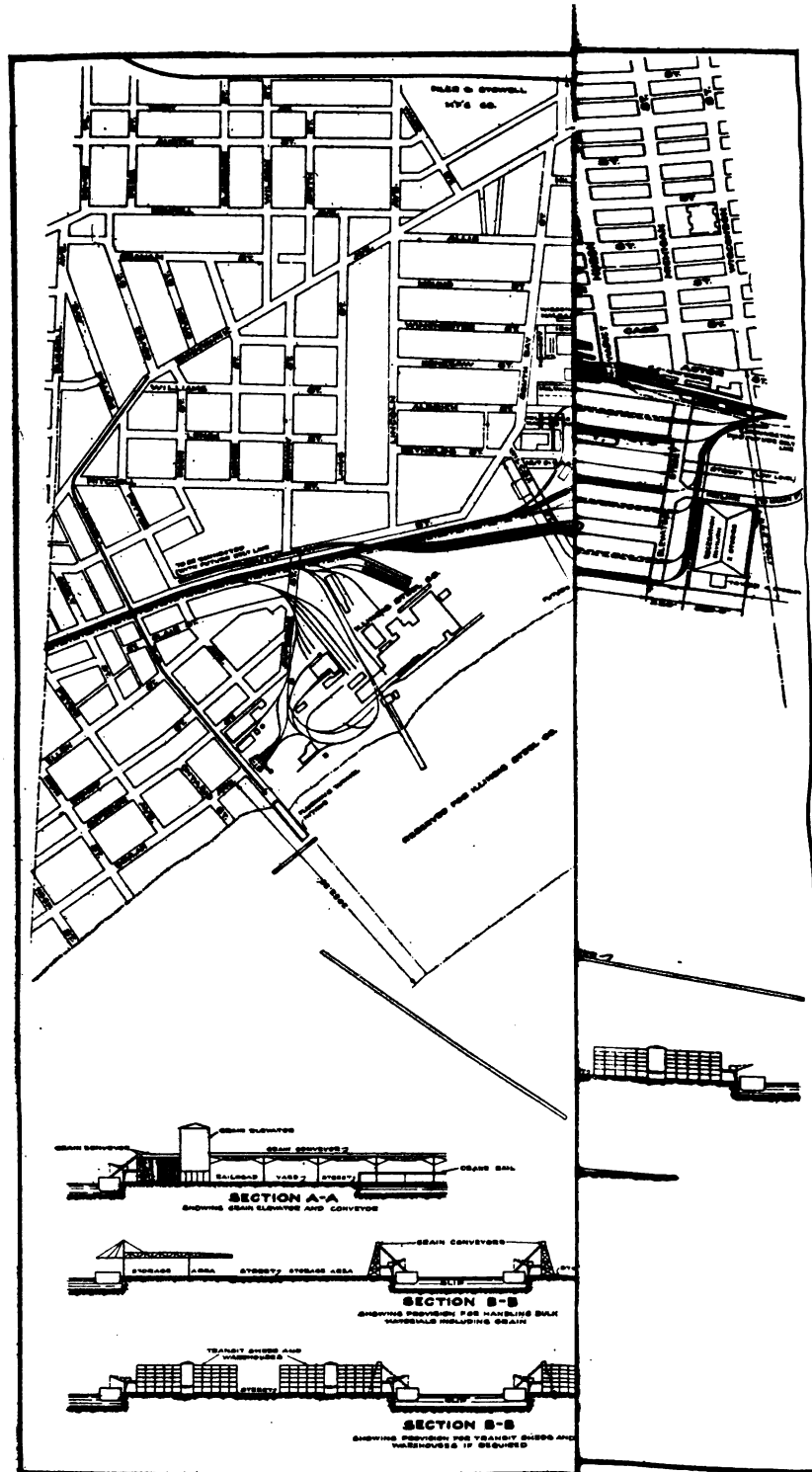


FIGURE 35

FIGURE 35-A



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and operated with convenience and efficiency, and with an entire avoidance of the evil of cumulative charges for switching between the various railway lines. Every first-class port having several trunk-line connections should have a similar unified belt railway system.

69. *Trucks.*—Adequate provision must, of course, be made for the economic access of trucks to the transit shed area. It may in some instances be necessary to allow such trucks to drive directly into the transit shed, either to the first floor directly from the street or over a viaduct to the second floor.

70. Figure 36 shows a proposed layout for the port of Milwaukee, and it will be noted that the whole plan is based upon the quay system. Here originally the terminals were along the rivers, and this was satisfactory for the smaller ships. Lake vessels have grown to such extent that it now becomes necessary to adopt a broader scheme. The National Government some years ago provided jetties to improve the entrance to the inner harbor, with a breakwater to protect this entrance and form a harbor of refuge. If the proper sequence of construction is followed, the plan shown in figure 36 will allow the protection of several miles of quay by means of the material excavated to secure the necessary depth for ships. The development on the south side of the entrance is intended mainly for bulk material, which makes up most of the present lake business of Milwaukee. The construction at the north side of the entrance is principally for package freight. Note that an approach for trucks is provided by means of ramps and viaducts to the second floor of the transit sheds, thus avoiding the many railroad crossings. In figure 23, the McKean Street Pier, No. 78–S, at Philadelphia, provides accommodations for trucks at the center of the ground floor, an arrangement excellent in many respects but tending to restrict the provision of railroad facilities.

71. *Lighterage.*—In many ports lighterage plays an important part in expediting ship turn around, especially where adequate handling facilities are also provided along the face of the wharf. Ship's gear then becomes available for additional handling, and this is best employed between ship's hold and lighters moored on the offshore side of the vessel. At the port of New York, where there is no railroad belt system, such lighters constitute a valuable substitute, and, in fact, may be said to form an inner belt. A large percentage of the shipping transfer business at New York is performed by means of lighters and car floats. Much of it is uneconomical, but nevertheless the lighterage system at New York is a necessary adjunct of the port.

72. In general, it may be said that packages of ordinary size should be handled direct between transit shed and ship, but that those of extraordinary size or weight are best disposed of at the offshore side of the ship by floating derricks or by steam lighters with heavy derrick equipment.

73. In such ports as Hamburg and London, where inland waterways handle a large part of the country's traffic, barge and lighter service to the offside of the vessel is particularly valuable. As we have seen in paragraph 18, the jetty system of the Royal Albert Dock South gives access to the ship for lighters on the inshore side also, without resort to breasting off the ship from its berth.

MECHANICAL EQUIPMENT.

74. While it is impossible to select the best means of handling without knowing the character of the various commodities, the method of transfer, etc., the general practice may be described. As already stated, the economic equipment of each terminal is in itself a special problem of the highest importance. The various descriptions and illustrations before given furnish some insight to the subject of handling, as instanced particularly by figure 2, showing the mechanical transfer of outgoing ore; figure 3, reclamation of ore from lake vessels; figure 4, export coal terminal at Norfolk; figure 5, export coal terminal at Baltimore; figure 6, storage and handling of coal or ore between rail and ship; figure 7, a similar operation for coal between river barge, stock pile, and ocean collier; figure 8, cranes for handling heavy packages between pier and ship; figure 9, the method of handling naval stores in barrels between open storage and ship; figure 10, arrangement for pumping oil or other liquid cargo between tank and ship; figure 11, the transfer of bulk grain between elevator and ship, the description also giving the method of elevation between hopper and bin; figure 12, wherein the grain subway at Manchester, England, is indicated, also the movable tower cranes on the quay of No. 9 dock, and the semiportal and roof cranes for the proposed new quay warehouse at Manchester; figure 19, transfer between grain elevator and ship; figure 29, the 30-hundredweight hydraulic cranes on the roof of a quay warehouse at Liverpool, England; and figure 35, the method of handling in and out of the warehouse where high stacking is permissible.

75. In general it may be said that hand operation is expensive and should only be employed where mechanical means can not be adapted to economical use.

76. *Ship's gear.*—Nearly all transoceanic cargo carriers are equipped with cargo masts and booms, rigged with blocks and falls operated by means of steam winches placed on the deck adjacent to each hatch. Such equipment is necessary unless the ships are to operate between certain fixed ports provided with handling apparatus for their loading and unloading. Even under such conditions it may prove highly advantageous at times to have ship's equipment available, as the ship may have to deviate from its regular route, or may in case of accident find it necessary to shift or jettison cargo.

77. Figure 37 shows the simplest method of rigging a ship's boom with a single fall for handling sling loads from hold to wharf or vice versa. This is known as a single whip, and is operated from a single drum of a hoisting engine, the hoisting engine being usually supplied with steam from the ship's main boilers or from a special donkey boiler.

78. Figure 38 shows a method of rigging two ships' winches and ships' booms with a Burton fall.

79. Figure 39 shows four steps in handling a load from ship's hold to wharf by means of a Burton fall. It will be noted that the first winch hoists while the second winch takes in the slack of the line; that when the load has been hoisted to a sufficient elevation above the deck of the ship, the second winch continues to take in

the line while the first one begins to slack away, thus transferring the load from one winch to the other, the fall which is rigged outboard finally delivering the load to the wharf or truck.

80. Figure 40 shows four steps in the handling of a single load by the whip and whip method. The ship's booms are fixed in the

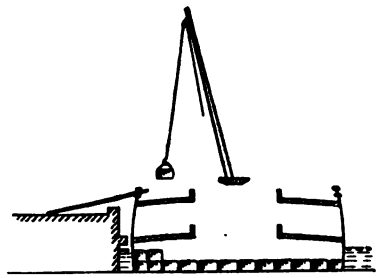


Figure 37.

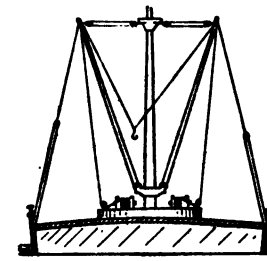


Figure 38.

same position as in figure 39, but instead of having a single hook on the line between the two booms each boom is rigged with a separate single whip. The operation is very much the same as that described for the Burton fall.

81. Figure 41 shows a combination of the two separate whips with the Burton fall method. In this case the single whip over the

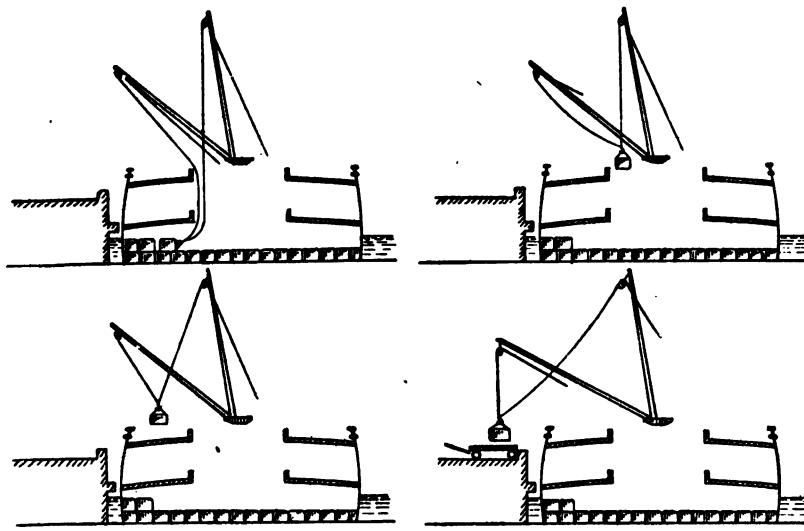


Figure 39.

hatch drags out the load and raises it to the deck, where the second hook is attached, after which the operation is similar to that already described for the Burton fall.

82. Figure 42 shows the rigging of ship's booms for the whip and trolley method. Here the fixed hook on the line is replaced by a movable trolley carrying a hook.

83. Figure 43 shows the rigging for the so-called marine transfe Here a special guide block is so arranged that it may be moved and out. The single whip passes through this guide block a does the lifting and lowering, while the guide block gives in a

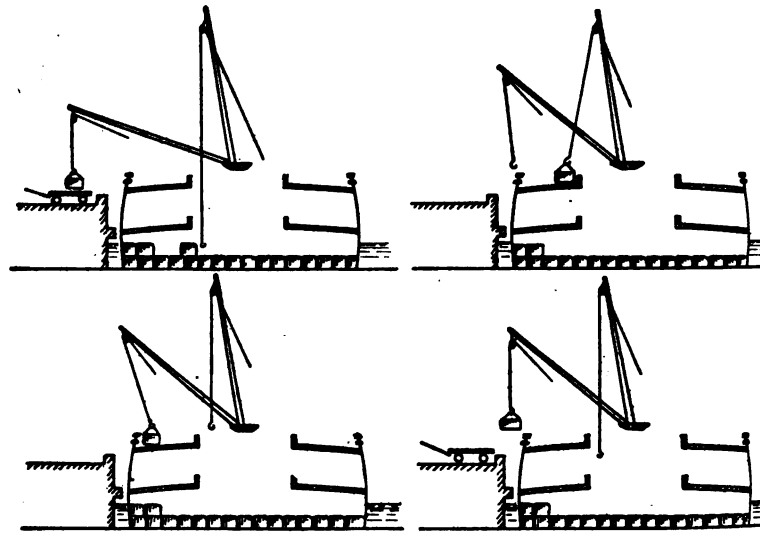


Figure 40.

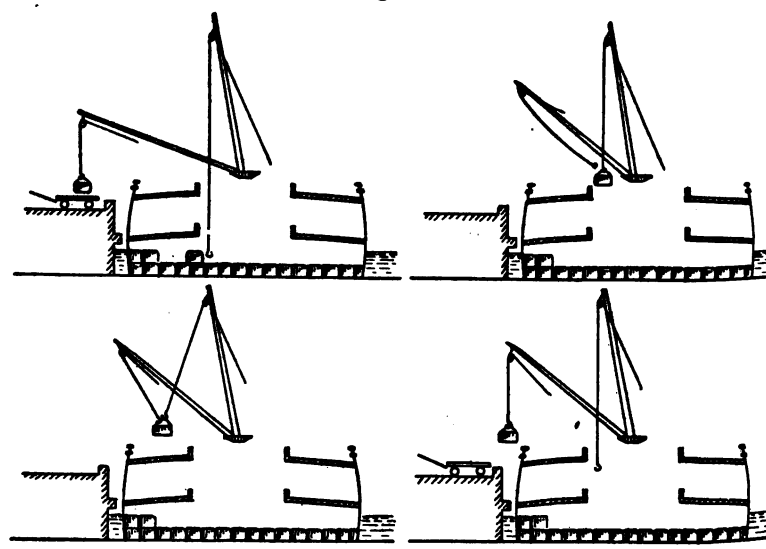


Figure 41.

out direction to the load. There are other combinations of simil nature such as, for instance, an inclined ramp leading from t ship's bulwarks to the wharf, the load being dragged up and do this inclined ramp, or, in special instances, a truck being operat thereon to take the load.

84. *Ship's gear in combination with portable winches and cargo masts.*—The above-described methods apply where there is no mechanical equipment ashore, and it may be said in general that under such circumstances the Burtoning method, or a combination of it with some other, is the most generally used and produces the best results. Where the side of the transit shed is placed close to the edge of the pier or wharf, as is common practice in New York and in many other American ports, it is usual to erect a girder

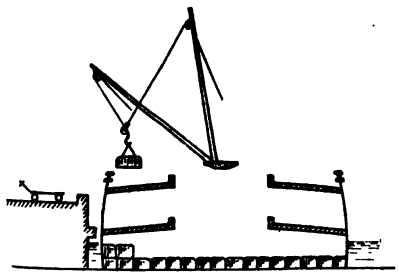


Figure 42.

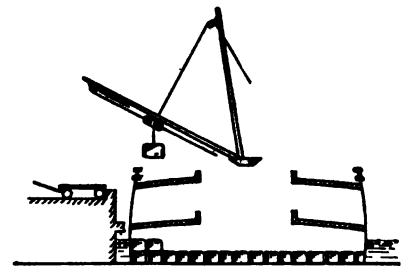


Figure 43.

system above the roof of the shed (fig. 44) provided with means of attaching blocks, each of which in combination with ship's booms and gear is rigged with a Burton fall. In this case a portable electric winch, supplied with electric current from plug-ins along the wharf, is used in combination with one ship's winch, instead of two ship's winches as above described, though the operation is entirely similar. These handling methods all have the disadvantage of requiring a separate man for each winch, with a signalman in addition to indicate the readiness and position of the load. Part

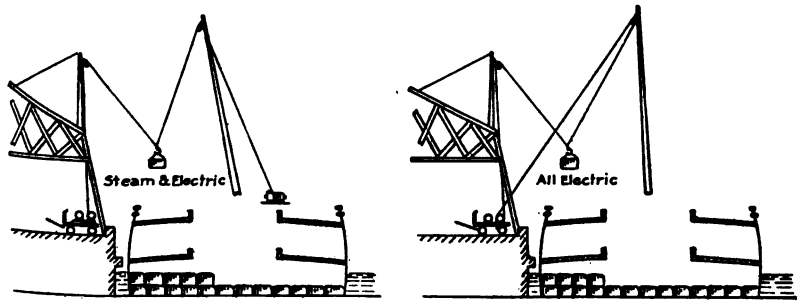


Figure 44.

of this difficulty may be eliminated, as shown in figure 45, by the employment of distant control apparatus of such size and weight as to allow its suspension around the neck of an operator, who may thus take up his position at the edge of the hatch, where he may observe the position of the load at all times.

85. *Wharf cranes.*—To supplement the ship's gear, or to take its place entirely, self-propelling cranes are frequently used. At the important ports of the British Isles and of continental Europe this is common, and it is not unusual for one crane, capable of lifting from

1½ to 5 tons, to be supplied for each 100 feet of quay. As the fir cost of the cranes is great, in comparison with that of portab winches, our port authorities hesitate to install them, and there at the present time hot debate as to whether or not they are econom cal. The main argument of those who oppose them is either th equally good results can be had by Burtoning, or that cranes can n show sufficient saving to earn interest on the investment. It is be regretted that the makers of crane equipment have not so far pr duced comparative cost data to give convincing proof of the val of their product; although it may be said that neither have the a vocates of ship's gear and portable winches proven their case. the face of the fact that the best British docks have such cranes a continue to provide them, and that British experience in the shi ping business is more extensive than our own, it would seem that may well hesitate before so building additional berthing space f ships that we can not hereafter install cranes. Undoubtedly su equipment will not pay unless the ship's berth is intensively us While one operator is sufficient for the cranes, two operators are

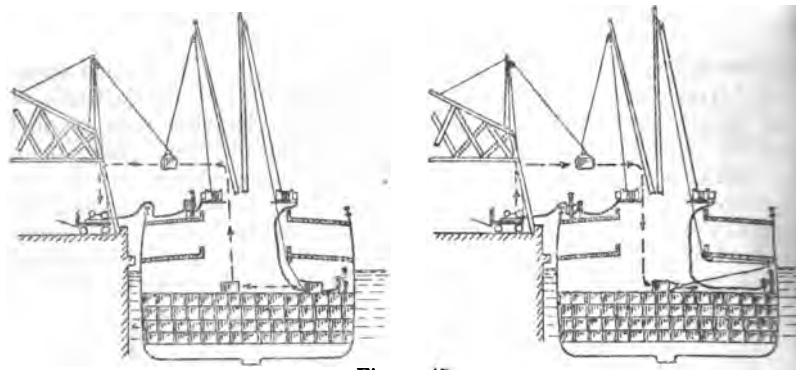


Figure 45.

quired, one for each of the separate winches. Furthermore, und usual conditions, the same operator will handle a crane the ye around, and will soon become more expert than can the most expe enced winchman who has to go aboard ship and operate any of t many types of winches, in good or bad condition, which may ha been installed. Furthermore, the crane is capable of depositing load over a wider wharf area than can be covered by the Burton and thus wharf congestion is avoided. Another point is that in or to justify itself the crane need not necessarily earn interest on investment. If greater expedition can be had with the crane th with the winch, ships and cars will be dispatched more rapidly, a will thus be available for their true functions as freight carriers. the case of the ship it has been repeatedly proven that the cost holding it an additional day in port will easily run from $2,000 $4,000. Furthermore, if a port can establish the reputation of tur ing ships around rapidly, its business will be enhanced, its popul tion will grow, new industries will spring up, and the entire comm nity will profit. All pertinent data should therefore be collected an

arefully studied before deciding upon the type of handling equipnent, which in turn will decide many general characteristics of the vater terminal.

86. *Types of cranes.*—Cranes may be divided into two kinds—(1) ixed and (2) movable. Fixed cranes are in general not well adapted o the handling of cargo. Where the single load is very great it is rue that it may pay to move a vessel under a fixed crane capable of andling the weight, but within usual limits such extraordinary oads are better taken as exceptions and handled by floating derricks orking at the offside of the ship. Movable cranes are usually self-ropelled. This propulsion may be hydraulic, as especially applied o cranes of the older type in English ports. It is generally electric nd, as the crane is seldom moved along the water front, but occuies practically one fixed position over the ship's hatch during an ntire loading and unloading, speed in this direction is not essential. he stock standard-gauge steam crane is well known and has wide sage. Under steam propulsion it is able to go anywhere on standrd-gauge tracks, and is therefore especially valuable for handling ulk material and packages over a comparatively wide area. This rane has not the height for satisfactory operation alongside ships, nd steam operation under such conditions is usually unsatisfactory s compared with the simplicity of electric control along the retricted space of a water front. The difficulty of height for satisactory operation at ship side is solved either by raising the crane n a tower, such as indicated by figure 12 (section of south quay, No. dock, Manchester, England), such cranes as this frequently having he tower built in the form of a portal, thus allowing a standardauge track beneath with clearance for standard cars or, to conserve harf space further, the crane may be built of the semiportal type, as ndicated by the section of the proposed quay warehouse at Manhester (fig. 12). Both of these cranes and that indicated at the ear of the proposed quay warehouse on the roof are of the revolving ype. It is usual also to build such cranes so that the boom may be aised and lowered. Thus the revolving type crane is enabled to deosit its load over considerable space, in this respect differing essenially from the so-called right-line crane. This latter type is well llustrated by figure 32, section A–A, which shows an excellent arangement. When in position for operation, the boom which furishes the in-and-out track for the trolley is in a nearly horizontal osition. The crane may in this instance take its load from the pron in front of the transit shed and deposit it in the ship's hold y the three operations of hoisting, traversing at right angles to the harf, and lowering into the hold, or it may, in reverse, hoist the load rom the hold, traverse it into the second story of the transit shed, nd there deposit it. Its one disadvantage is that, unless the space nder the inboard end is kept clear, delay will result. Concentration nder the inboard end may, however, be relieved considerably by the e of gravity roller paths radiating from the central point at which ads are deposited. As will be seen from the dotted lines, before aversing this right-line crane along the wharf the boom must be ised, both for the purpose of clearing the ship's rigging and to clear s inner end so that it will not be obstructed by the building columns.

Whereas the rotating crane has separate motors for traversing along the wharf, rotating the boom, and hoisting the load, the right-line crane has separate motors for traversing along the wharf, trolley traverse in and out, and hoisting. Cranes of both types must be equipped with means of elevating and lowering the boom. This latter may or may not be a separate motor.

87. Figure 29 shows in outline a 30-hundredweight hydraulic crane movable along the roof of a shed at Liverpool. This crane has one track above the wall of the building and one at the peak of the roof. It pivots around the vertical posts just above the front truck. Note the 20-hundredweight fixed hydraulic crane at the rear of this same shed. The front crane is required to be movable, as it would be impracticable to move the ship. The back crane is quite efficient as a fixture, as only a truck must be moved under it.

88. While there are many other special designs of cranes, the above-named illustrations should suffice for general types.

89. *Monorails and telphers.*—As the name implies, this equipment consists of single tracks for hand or self operated trolleys. We have already seen in figure 9 the application of this method to the open storage of rosin at Jacksonville and in figure 35 its application to cotton-bale and similar storage at Manchester, England. Such trolley systems are usually installed on parallel overhead tracks inside a building, with occasional switches or crossovers, usually more or less complex in operation. While highly satisfactory for special purposes where it is not necessary to cover the entire floor area, they are usually not economical in their application to transit sheds where it should be practicable to deposit loads at any point within the building. Such an installation on one of the Baltimore & Ohio piers at Baltimore is said to be used quite infrequently, although it is capable of running outside the shed to the ship's berth and alongside the railroad cars inside the shed.

90. *Conveyors.*—While monorails and telphers are, of course, conveyors, the term as ordinarily used implies continuous motion as of an endless belt or chain. The variants within the limits of this description are manifold. Again, equipment of this sort may be fixed or in portable units. The belts in the grain subway at Manchester, figure 12; those in the New Orleans system between the grain elevator and the wharf, figure 11; and those in the conveyor gallery, figure 19, are illustrations of the application of fixed conveyors for bulk materials. Under such circumstances, by means of rollers set in three different planes, the surface of the belt is troughed to give it greater capacity than it otherwise would have and to prevent the spilling of the granular material. Similar belts, usually of rubber, running on horizontal rollers and therefore having a flat surface, are used for the transportation of packages of various descriptions. They are especially applicable for use in manufacturing plants but may in certain instances be adapted to terminal conditions. The cold-storage warehouse, for instance, on the quay at the Royal Albert Dock, London, has such a belt system fixed in positions just inside the second-story cargo doors for transfer of quarters of beef or dressed mutton. The cross transfer in this case is taken care of by portable belt sections, as hereafter described for other purposes. Such fixed belt systems may run horizontally, or at a considerable angle or, where the angle

FIGURE 46

FIGURE 48

FIGURE 47

FIGURE 47-A

is too great to retain the material by friction, cleats are fastened to the belts at intervals.

91. *Slat conveyors.*—Similar arrangements may be produced by the combination of chain belts and wooden or metal slats. As in the case of belts, fixed systems of this sort are more particularly applicable to manufacturing plants, but these also may be adapted to terminal use. Figure 46 shows such a fixed slat system.

92. *Pan and bucket conveyors.*—In the construction of these a metal pan or metal bucket takes the place of the wood or metal slat. Where fixed in position they are more usually applied to manufacturing work, but may be used at terminals, as, for instance, for the elevation of grain from car hopper to storage, as described for New Orleans and Manchester.

93. Figures 47 and 47A show views of such installations applied to the elevation of bunker coal from lighter or car to side ports of ship.

94. *Chain-hook conveyors.*—These consist of an endless chain fixed in place on a ramp or slope between transit shed and edge of wharf, and are particularly applicable in conection with hand trucks in the loading and unloading of coastwise or other vessels equipped with side ports, and such apparatus is especially useful where there is a considerable tidal variation. Under such conditions the ramp is hinged at the top so that its lower edge may be adjusted to meet the between deck of the ship. Longshoremen pushing hand trucks are able to transport very considerable loads on the level, but are quite unable to push such loads up much of a slope. Under such conditions the operator pushes his truck over the hooked chain which is in continuous motion (fig. 48). The axle of the truck is engaged by the hook of the chain, and the load is pulled up by this means, the operator simply steadying the truck in its ascent of the incline. The same operation is applicable in reverse, and is necessary for steep slopes, as otherwise there would be danger of the load getting away from the truckman.

95. *Portable chain and belt units.*—Practically the same method described in the preceding paragraphs for fixed chain and belt systems is used in connection with portable sections of the same general character, and these separate units properly applied are quite economical in their use at water terminals. A belt or slat system in separate units, each usually from 15 to 25 feet long, may be placed from ship's side to practically any point in the transit shed, and may by means of special elevating units at either or both ends of the line convey material in bags or bales of limited weight aboard ship, or may take such material from the breakdown point at the ship's sling, convey it into the building, and stack it at considerable height.

96. Figure 49 shows such a system taking material in bags from the breakdown point of the ship's sling, transferring them inside the transit shed, and stacking them at its extreme end.

97. Figure 50 shows a special arrangement for transferring bags of material from the transit shed to the edge of the ship's hatch and there chuting it into the hold. Such separate units of belt or slat conveyor are usually operated electrically. Each unit may have its own small motor, or an occasional motor-driven unit may be used, the others being driven from sprockets and chains.

98. *Gravity conveyors.*—These may be simply straight, metal-lined chutes, as illustrated by figure 51, or they may be single or

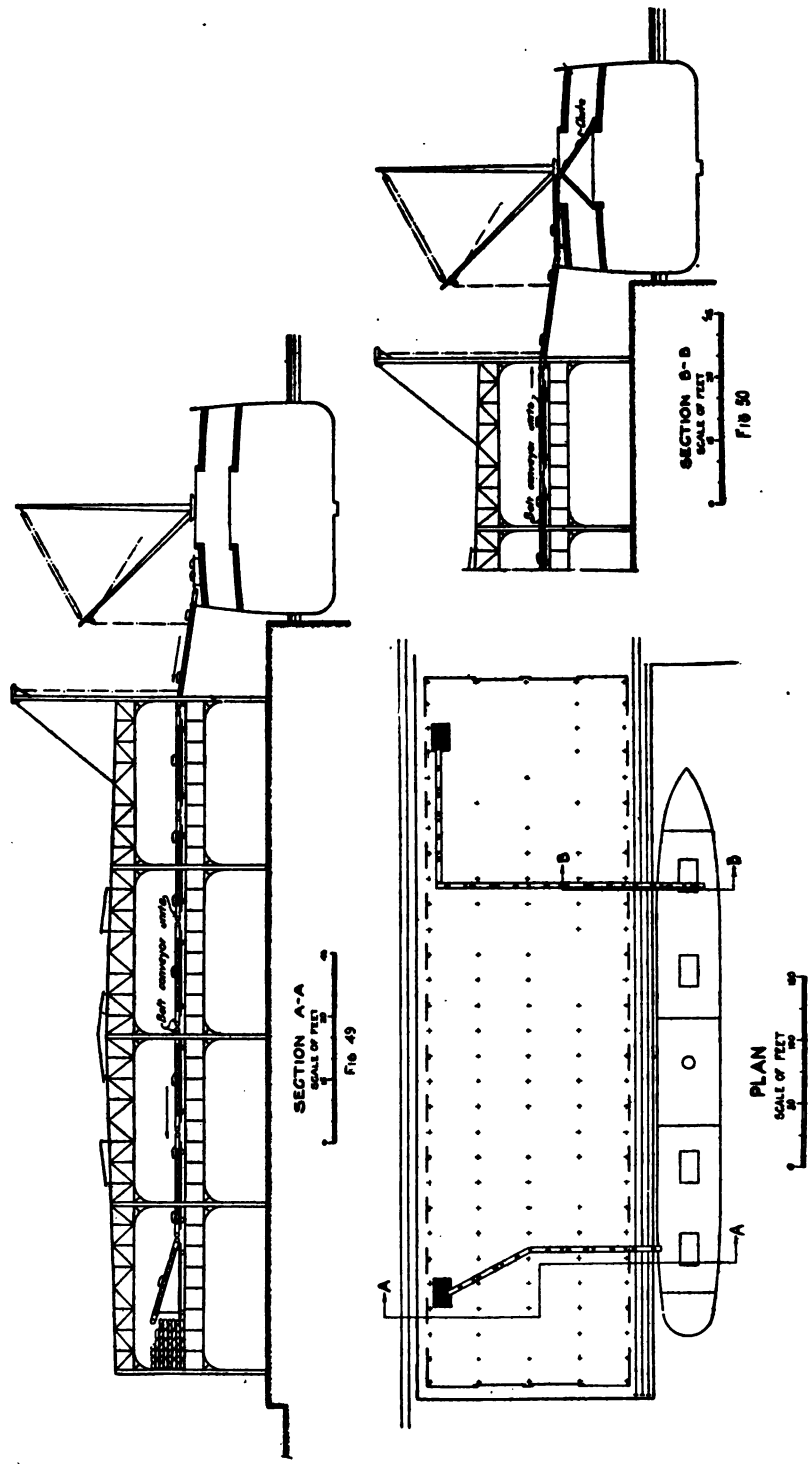

SECTION A-A
SCALE OF FEET
FIG 49
SECTION B-B
SCALE OF FEET
FIG 50
PLAN
SCALE OF FEET
A
B

FIGURE 53

FIGURE 52

FIGURE 51

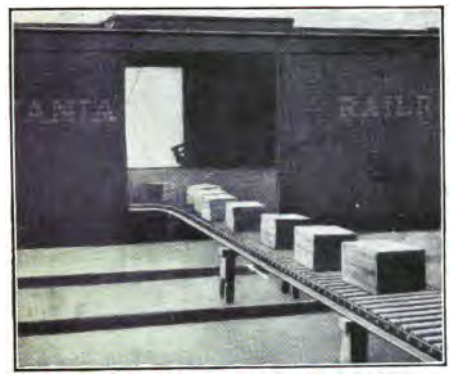


FIGURE 54

FIGURE 55

FIGURE 56

double spirals, as illustrated by figures 52 and 53. They are generally installed in factory or warehouse buildings of the loft type, but are equally applicable for conveying material from upper to lower floors of double or multidecked transit sheds.

99. *Gravity roller conveyors.*—These are useful for transferring packages, either in a straight line or spirally, where it is not desirable to use a high angle of slope.

100. Figure 54 shows a straight section of this type of conveyor, and figure 55 is a spiral section of the same general construction, which consists in the main of side bars or guides supporting metal rollers on ball bearings. With such construction a very slight angle is sufficient to keep packages moving.

101. *Piling machines.*—These may be inclined or vertical. If inclined, they are in all essentials a continuation of the portable sectional belt or slat system, as hereinbefore illustrated (Figs. 49, 50). In general terms such a piling machine may be said to consist of a portable section carrying an endless belt or slat conveyor, hinged at one end and arranged, by means of a gallows frame or similar device, to raise and lower the opposite end. Under such arrangements, packages coming from the horizontal belt unit are fed upon the elevating section and raised to the desired height for stacking.

102. If of the vertical type, such machines are movable elevators, with a platform which travels up and down in vertical guides. They may in certain cases be operated by hand, but for quicker movement each may be equipped with its own motor. They can be used in such restricted spaces as would not accommodate the inclined elevator, and they are commonly built for heavier loads than is the inclined elevator. Figure 56 shows the general type of such portable elevators.

103. *Fixed elevators.*—These are freight elevators of the same description as those used in city buildings. They may be built for small packages, or of such size as to accommodate several trucks at one lift. They are frequently installed in double decked transit sheds, but are more especially applicable to multi-storied warehouses.

104. *Trucks.*—These may vary in type from the usual two-wheel hand truck, through four-wheel hand trucks to those propelled by power. The hand trucks are too familiar to require any special illustration. They are only economical over short distances. The limits of hand trucking distances are not easily defined, as they depend upon many elements. Some authorities place this limit at 200 feet, but it is obvious that each problem requires its own separate solution. Trucks may be again divided into the stationary platform and the elevating-platform type. For the elevating-platform variety (Fig. 57) separate trays on short legs are provided. These trays are set in position and loaded while the elevating platform truck continues handling other trays. When a tray is ready for transfer the elevating platform truck is shoved under it, the elevating device is put into operation, and the tray is lifted into place and carried to its destination. This truck is frequently operated by hand, but may have its own motor power.

105. *Self-propelling vehicles.*—These are motor trucks, but for terminal purposes the description is confined to the small vehicles used exclusively in and around terminals. They may be operated by gaso-

line motors, but the generally accepted power is the electric storage battery, motor drive. They may or may not be equipped with elevating devices for handling separate platforms. There are many makes of such storage-battery trucks. Figures 58 and 59 illustrate two of these, the former having an elevating device for separate platforms.

106. *Tractors and trailers.*—Motor trucks are being used more and more extensively at terminals. Single trucks carrying their own loads are applicable where the business is not sufficiently great to require heavy single drafts, or in restricted spaces where a train of trucks could not be employed. For heavier drafts and greater business, the tractor and trailer system is coming into general use. This consists of a motor truck quite similar to those already described, equipped to draw trains of trailer cars after it. Figure 60 shows such a train. The front wheels are usually on casters, and the trucks when properly made, track remarkably, and are thus capable of being drawn through narrow aisles and around sharp turns.

Such trailers are very efficient in combination with flat wooden or steel platforms the approximate size of the platform of the trailer. Cargo is assembled on these platforms, loaded upon the trailer, and drawn to the ship's side, where the Burton fall or crane transfers the load to the ship's hold for stowage. When a sufficient number of these simple platforms has been accumulated in the vessel to make a sling load they are transferred to the wharf for reuse. The same operation applies equally well in reverse. The platforms have sling loops attached to their four corners, with two wooden angle bars drawn over the loops to engage the top edges of the packages to be transferred, thus distributing the pressure of the rope and preventing the cutting of the edges of the packages.

107. *Floating equipment.*—There are many types of floating equipment used for the transfer of both bulk and package commodities to and from ship. We have already noted that for packages of extraordinary size or weight it is uneconomical to provide hoisting apparatus on the wharf or quay, and that much freight should be transferred from the offside of the vessel by means of floating derrick or steam lighter.

108. *Floating derricks* frequently are of the simple mast-and-boom type, not differing materially from similar arrangements ashore, but rigged upon a pontoon or float to be towed or self-propelled to any point in the harbor. They may be of the right line overhanging boom, or of the swinging-boom type, and have any capacity required. Figure 61 shows the barge crane *Samson*, belonging to the Mersey Dock and Harbor Board at Liverpool. This crane has a capacity of 30 tons at 64 feet radius and 20 tons at 74 feet radius. The height under the block from the water at the greater capacity is 80 feet and at the smallest capacity 65 feet. Figure 62 shows the electrically operated floating crane in use at the United States navy yard at Norfolk, Va. The pontoon of this crane is 85 feet wide and 140 feet long, and the lifting equipment consists of 75-ton hook blocks fixed on the jib, and a 25-ton auxiliary hook block. The crane will handle 150 gross tons at a working radius of 105 feet. Floating derricks for handling ordinary cargo are generally of much simpler design and of less capacity than either of these cranes.

58—1

FIGURE 57

FIGURE 58

FIGURE 59

FIGURE 60

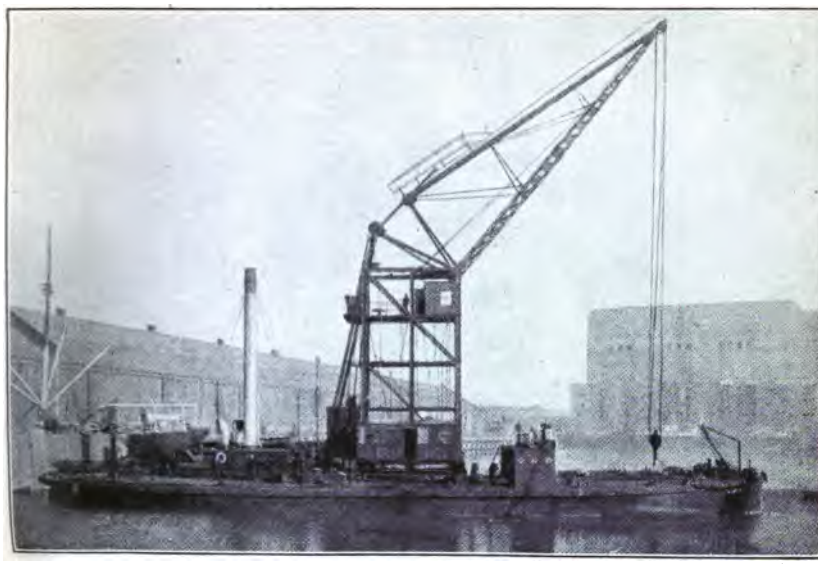


FIGURE 61

FIGURE 62

FIGURE 63

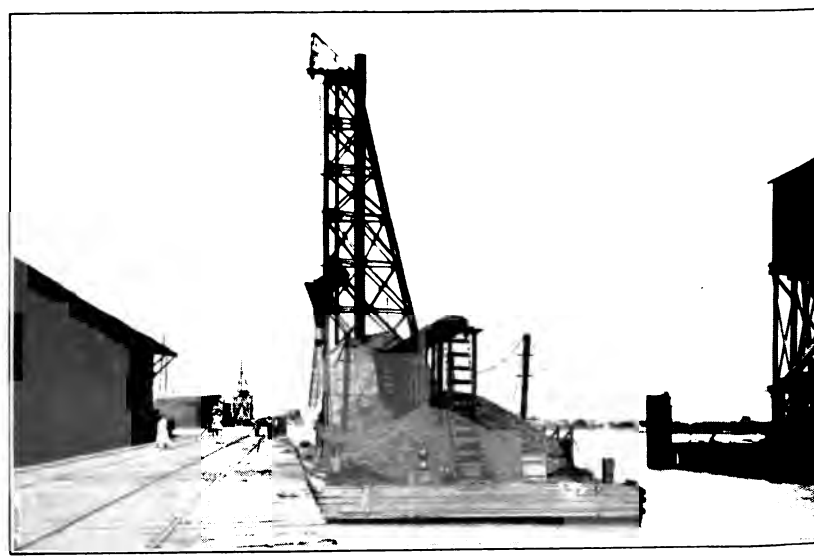


FIGURE 64

109. *Steam lighters.*—These in general terms may be said to be harbor tugs constructed with the deck houses entirely aft, and with unusual length of deck forward for the accommodation of cargo. The derrick equipment is placed just forward of the superstructure, and is capable of covering the deck area of the lighter and plumbing the hatch of the ship.

110. *Suction grain elevators.*—These are principally used for import grain in bulk. Flexible suction pipe is carried into the hold of the vessel. The suction pumps are then started and deliver the grain through flexible extension pipes ashore or to barge alongside.

111. *Chain belt bucket units for grain.*—While these do not come under the head of floating equipment, their description belongs with the suction grain elevators. Portable metal frames of light construction support an endless chain apparatus with small metal buckets. The unit is suspended from the ship's boom, or from a crane ashore, into the grain in the vessel's hold. Operated by its own motor, the apparatus digs the grain from a hold, discharging it into a spout connected with a gravity chute, which in turn discharges the grain into lighters alongside or ashore. The whole apparatus, though much lighter in construction, is quite similar in arrangement to the portable bunkering units hereinafter described in paragraph 115 and illustrated by figures 47 and 47A.

BUNKERING EQUIPMENT.

112. Present-day ships are either coal or oil burners, and may be bunkered at a wharf, as described for export coal, or through a pipe from oil tanks on shore. Such operations, however, require additional time over and above that consumed in discharging and loading cargo, for which reason the accepted practice in most ports is to bunker the ship while handling cargo. If the ship has oil-burning equipment, the oil is pumped into ship's tanks from barges alongside. If the fuel required is coal, lighters of coal are brought alongside and the vessel bunkered by the means of single whips and baskets filled by men with shovels, or by mechanical apparatus self-contained in the coal barge, or by separate barges and elevators. Figure 63 shows a mechanically equipped barge used at Rotterdam for this purpose. This coal barge is divided into compartments, underneath which runs a belt conveyor so arranged as to continue its course by an arm which makes an angle of about 45 degrees with the horizontal. Each compartment has a sliding door through which coal is deposited upon the belt conveyor, thence carried up the inclined arm and poured down a funnel or chute into the side or deck ports of the vessel. The coal is automatically weighed while it is carried along the belt conveyor, thus offering no interruption to the transfer of the coal. This barge is equipped with twin screws and moves rapidly from one ship to another. Figure 64 shows a coal bunkering barge used in the harbor of Mobile, Ala.

113. Another type of coal-handling barge used in the same port transfers coal from an ordinary barge to its own belt conveyor, and thence into the bunkers of the vessel. The capacity of such device ranges from 250 to 500 tons of coal per hour.

114. A very simple rig which is much used both in Europe and the United States for mechanical bunkering is shown in figure 65. It consists essentially of a float carrying a tower on which is suspended a double cantilever arm running athwartship. The two arms are hinged at the base in order that they may be triced up for clearance purposes. In operation the barge is lashed alongside the ship; one arm is extended over the deck of the ship and the other over a coal barge moored on the offside of the bunkering machine. A clam-shell bucket digs coal from the barge and delivers it aboard the ship.

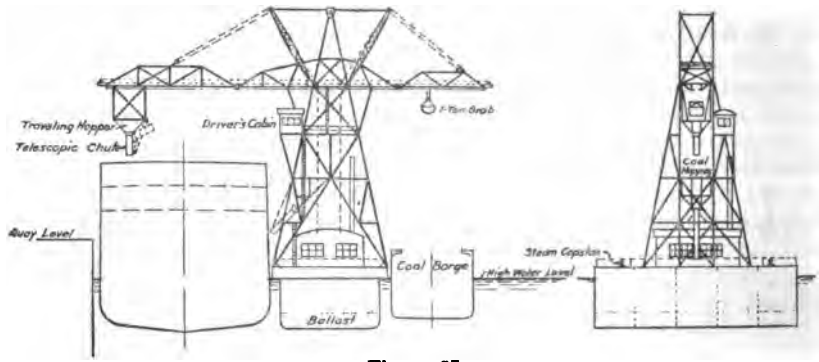


Figure 65.

115. *Portable bunkering units.*—Figures 47 and 47–A show a coaling machine much used in New York Harbor. Except that it is necessarily heavier, it is not materially different from the portable chain belt bucket grain elevator. The chain belt and buckets are inclosed in a casing in order to prevent spillage and for protection from the dust otherwise blown aboard ship by the wind. This machine is operated by its own motor. The buckets discharge into a chute which leads into deck or side ports of the ship. The machine may be suspended from the ship's own gear or, if bunkers on the wharf side are to be fed, on cranes or booms rigged from the wharf shed.

116. *Car floats.*—These are useful for the transfer of railroad cars from one point to another within a harbor where bridges of the ordinary type and railroad belt lines are not available, as at New York. They are broad-beamed, flush-decked lighters of considerable length, provided longitudinally with two or more standard-gauge tracks. They may or may not be self-propelled. They are run longitudinally into a special slip, which at its shore end is provided with tracks running over an adjustable apron to correspond with the tracks on the lighter. Freight cars are thus transferred from shore to float and transported to the desired point.

117. *Repairs and reconditioning.*—Every first-class port should be capable of repairing and reconditioning ships of every size and type operating in the port. Such repair plants must necessarily be operated by those skilled in ship work, and, as many of the operations will be upon the hull or outer mechanism below the water line, dry-docking apparatus will be required. Also ships become foul with marine growths and must be scraped, cleaned, and repainted one or more times per annum. Every first-class port will therefore require one or more dry docks. Every ship should be expected to spend

from three to five days per annum in dry dock for painting, realigning of tail shaft, etc. For extraordinary repairs the time may be weeks or even months. It is not the intention to enter into the details of dry-docking and repairing, but it is desired to draw attention to the fact that ports should be fully equipped in this respect.

118. *Types of dry docks.*—Dry-docking apparatus is of three main classes:

(1) The graving dock built to accommodate ships of all sizes and consisting essentially of an excavation into the foreshore of the harbor, lined with masonry and provided with a gate through which ships may enter and depart. This differs from the wet dock described for foreign ports in that when the gate is in its seat the interior may be pumped dry and the contained vessel landed upon a set of longitudinal blocks. Under such conditions its sides and bottom are accessible for repairs or cleaning.

(2) The floating dock consists of one or more sections of pontoon with side walls. A longitudinal set of keel blocks extends midway between the side walls on the decks of the pontoons to receive the ship. In operation the dock is sunk until the tops of the keel blocks are a few inches below the keel of the ship, when the ship is floated into the dock and centered over the blocks. The pontoons are then pumped out, and as the water is removed from them the dock engages the keel of the ship and lifts it out of the water, when it is available for repairs or cleaning.

(3) The marine railway consists of a system of tracks leading from the shore of the harbor and running at a slight inclination into the water. Upon these tracks a cradle is run in and out by means of a winch at the head of the slip. The cradle has a system of longitudinal blocks at its center to support the keel of a ship. In operation the cradle is run down the incline until a sufficient depth of water exists over the keel blocks, when a ship is floated in and centered. The cradle is then hauled up the incline until it engages the keel of the ship, and the vessel is thus hauled ashore for repairs or cleaning. Such marine railways are seldom used for ships having a haul-out weight of more than 4,000 tons. For ships of this latter size the depth of water required is greater than the naturally maintained depth close to shore for most of our harbors.

Floating dry docks are constructed of much larger capacity than the marine railways. The largest floating dry dock in New York has a length of 722 feet 6 inches, a width of 105 feet, and a lifting capacity of 30,000 tons. The greatest draft over the blocks is 30 feet. Such a dry dock constructed of timber and protected against the ravages of marine borers should be serviceable for many years. Its cost is probably not more than two-thirds that of a masonry dock of similar capacity. It has the additional advantage that it can be transferred for use at another site.

Commercial repair concerns usually provide themselves with dry docks of this description. Intensively used, they should return fair interest upon the investment. Masonry dry docks are so expensive that only under rare conditions can they be considered a good commercial venture. Nevertheless, the necessary dry docks must be provided, and the progressive port will build its own dry docks if private enterprise fails to do so. Ships will naturally seek the port which is capable of taking and providing full cargo and where

there will be a minimum of time required in port, but with import capacity available and with ample tonnage for export, that port will prosper most which has all auxiliary facilities. The transfer of ocean-going ships from one harbor to another to secure the necessary dry-docking facilities is an added expense, and the ambitious port will be foresighted in this direction.

SEAPORT TERMINAL PLANNING.

119. *Harbors.*—A protected harbor of sufficient depth to accommodate ships of the largest class required for commerce is the first essential.

120. *Channels.*—Many excellent harbors while possessing the requisite depth and protection inside are limited with respect to the natural depth over the outer bar and entrance way. Under such conditions, entrance works, or dredging, or both, may be required. In general it may be said that the National Government meets the demands of commerce with regard to main channels, while leaving to the State, the city, or local commercial interests the provision of all other facilities, inclusive of channels to particular locations.

121. *Ship characteristics.*—The average deep-load draft of 535 ships built in the period from 1889 to 1893 was 20.6 feet, while a similar average for 1,343 vessels built between 1914 and 1918 was 23 feet. The average deep-load draft of steam vessels built during the five-year period from 1914 to 1918, was as follows: 5,000 to 6,000 gross tons, 25.3 feet; 6,000 to 7,000, 27 feet; 7,000 to 8,000, 27.4 feet; 8,000 to 9,000, 28.4 feet; 9,000 to 10,000, 28.7 feet; 10,000 to 11,000, 28 feet; 11,000 to 12,000, 28.4 feet; 12,000 to 13,000, 29.3 feet.

122. The greatest deep-load draft of any vessel built up to and inclusive of the year 1893 was 30.4 feet. For the period 1894 to 1898, the greatest deep-load draft was 32.2 feet, three ships of this draft having been built, and in the same period a total of seven ships of greater than 30-foot draft. During the period 1899 to 1903, inclusive, the greatest deep-load draft of any ship built was 36.9 feet, with three ships 36 feet or over, and a total of six ships of greater draft than 30 feet.

123. For the period 1904 to 1908, inclusive, the deepest load draft of any ship constructed was 37.3 feet, 2 ships of this draft having been built, the drafts of the 10 largest ships ranging 33 feet and over.

124. For the period 1909 to 1913, inclusive, one ship of 37-foot deep-load draft was built, with a total of seven having deep-load drafts greater than 30 feet.

125. For the period 1914 to 1918, inclusive, two ships, the *Bismarck* and *Leviathan*, were built, with deep-load drafts of 41.3 feet, which is the greatest draft for any ship now in existence. In this same period the 10 greatest ships were built with deep-load drafts ranging from 33.3 feet to 41.3 feet. It should be remarked, however, that practically every one of these ships is of the ocean-liner type plying between fixed ports and dependent largely upon passenger traffic for its revenues.

126. Maj. Gen. W. M. Black, United States Army, retired, figures that out of 14,513 steamships listed in Lloyd's Register for 1918-19,

81.45 per cent have a draft of less than 25 feet, and 99.32 per cent draw 30 feet or less, leaving a percentage of 0.68 vessels of over 30 feet draft. This preponderance of vessels of less than 30 feet draft is illustrated by the fact that in the first six months of 1914, out of 4,476 ships which paid pilot fees at the port of New York, 4,402, or 96 per cent, drew 30 feet of water or less. Only 28 of the ships drew more than 35 feet. Gen. Black also furnishes the following table of the various classes of ocean carriers:

Tonnage.	Average.	
	Draft.	Length.
Gross tons:	*Feet.*	*Feet.*
2,000 to 3,000	22	270
4,000 to 5,000	24.3	270
7,000 to 8,000	27.6	377
9,000 to 10,000	29.2	400
12,000 to 13,000	29.7	560

It may be said then that unless a port has the assurance of handling the very largest liners, channels which will accommodate a draft of 30 feet will usually be sufficient.

127. *Tides.*—The tidal variation of the port in question should be considered. If the distance from the terminal to the open sea is not great, ships may take advantage of high tide in which to reach their berths. If, on the contrary, the tidal variation is small, the channels must at all points be dug to the greatest depth required. In all cases the depth over the outer bar should be sufficient to take into account the ocean waves in order that the ships in crossing the bar may not be let down upon the bar and injured.

128. *Available water front.*—The extent of the water front available for development must, of course, be taken into consideration. If the port is, for instance, located upon a comparatively narrow river, the extent of shore line both for immediate use and for growth must be examined. We have seen that at Jacksonville, had the city or State authorities been sufficiently foresighted and taken hold of the situation from the start, there would have been available for port development 10 miles of water front, probably ample for almost unlimited future. If, on the other hand, the water front is quite limited, it may become necessary to adopt a pier system, or even to build basins into the land. In this connection the value of water-front real estate is important. The New York Central & Hudson River Railroad in building its passenger terminal in the city of New York, took the high value of the ground area fully into consideration, and the result is a station upon which has been built a structure of many stories, that which is not necessary for the station proper being used for general office purposes. Such reasoning is applicable to the water front, provided only that proper bearing may be had at reasonable depth for the building foundations.

129. *Character of exports and imports.*—Before proceeding with the design of a terminal it is, of course, necessary to know the character and quantity of each of the commodities to be handled. A merchant about to engage in a new business will, beyond doubt, give

careful consideration to the commodities he proposes to handle, the source of supply, and the market for their disposal. The same method of reasoning should be applied to the port. The port city proposing to build up an overseas business should determine the territory naturally tributary to it and obtain reliable figures both as to commodities available within that territory for export and the possibilities for the placement of imports. The export commodities will give a fair insight to the selection of the foreign ports of call which ships may use to dispose of their cargo, and the cargo available at these foreign ports will be an index to the possibilities of placement in this country. While it can scarcely be expected that exports and imports will be equal, this is the ideal to be kept in view, and it should be further borne in mind that in order that the shipping business may pay, the port must be prepared to accept at least a fair percentage of imports in order that it may dispose of its exports.

130. *Open and covered wharfage.*—We have heretofore seen that certain commodities are satisfactorily handled in the open, and that many of them require open wharfage for their most economical transfer. The principles of the design of open terminals have already been sufficiently discussed. We will, therefore, devote our discussion to the planning of a terminal for miscellaneous cargo which will require covered area for transfer between rail and ship. We will further assume that the length of shore line available is comparatively restricted, and therefore held at a high price per foot. The shore line available for development will be considered to be located upon a comparatively wide water area, the main channel leading through the harbor being approximately one mile from the shore line, the intervening water between channel and shore line being shoal. The bottom of the bay is covered with silt to a depth of several feet, below which there is sandy clay, and then pure sand to a depth of 50 feet, below which is ledge rock, so that standard timber piles of ordinary commercial length will reach firm bearing and at the same time the necessary depth may be obtained by pump dredging.

131. *Railways.*—We will assume that the land for a considerable distance behind the shore line is fairly high, dry and level, so that no particular difficulty is to be anticipated in the construction of the necessary highways and railways. We will assume further that the city is already served by several trunk line railways and has good streets and roads. Other things being equal, the terminal should be located close to the city proper in order to have available the necessary labor and material market. Otherwise, special provision must be made in the way of trolley lines, etc., to accommodate the necessary passenger traffic. The terminal will either be located close to the existing railways or railway extension must be had to the site, and in any event, ample space must be reserved for capacious railway yards, and, in order that the business of the port may not be handicapped by unnecessary and excessive switching charges, a unification of the railway systems entering the port must be had either by means of an independently operated belt line or by the equivalent of such line run by a combination of the railways for the common good. We have already seen (par. 68) that such belt systems at New Orleans and San Francisco are owned and administered by the

State authorities. At Norfolk, Va., the belt line is owned jointly by the several railroad systems which terminate at the port.

132. *Piers and slips.*—The above-assumed conditions indicate that in order to develop sufficient water frontage we must use a plan of alternate piers and slips. Obviously, if each pier is to be approximately 1 mile long, the slips between piers must be sufficiently wide to enable vessels of the largest size using the port to navigate between ships lying at the faces of the piers. We will assume further that the business of the port requires offside lighterage to ships, and that upon occasion it will be necessary to breast off ships on both sides in order to place coal barges between pier and ship for bunkering simultaneously with the loading and unloading of cargo. Two ships of 70-foot-beam, plus 4 lighters of 30-foot beam, give a width of 260 feet. Allowing a minimum width down the center of the slip between ships and lighters of 100 feet gives a total minimum width of slip of 360 feet as the least desirable. As our pier is to be of permanent construction and additional width of slip can not be made without tearing out part of this construction, we will, to provide for future growth and allow comfortable clearance, assume a width of 400 feet.

133. *Floor space under cover.*—In order to determine the necessary floor space for the assemblage and classification of cargo, it is necessary to adopt a measure of tonnage. We will, of course, expect to accommodate ships of all sizes engaged in overseas traffic, but as the economic size is constantly growing, and small ships for transoceanic carriage are no longer considered economical, we will adopt as our measure the 10,000-ton dead-weight ship, and based upon actual ship design, we will assume that such a ship is capable of bringing 8,500 cargo tons in and taking the same quantity out. Such a ship will usually be somewhat less than 450 feet long, but assuming that with end clearance it occupies a 500-foot berth, and that its cargo will be accommodated in the transit shed within the 500-foot length, we will be in position to figure the floor area, and hence the width of shed required. We will further assume that the full export cargo is to be assembled on the first floor of the shed ready for the ship when it comes in and that the entire second floor will be available for the import cargo. This is a logical arrangement, since in the ordinary case the cargo will be assembled from railroad cars and city trucks on the first floor, and, for a ship of this size, the import cargo must ordinarily be lifted as high as the second floor before being transferred by crane or Burton fall to the pier. Also, this will give us the advantage of gravity to transfer the cargo from the second deck to the railroad cars or trucks. As in this country ships usually bring in less than full cargo, there will be some excess space on the second deck, but this will be available for waiting room for passengers, for temporary stowage of their baggage, and for the offices and other requirements of the customs service.

Returning then to the first floor of the shed, and the required area for export freight, it should be noted that a ship ton may be taken either at the actual weight or according to space measurement at 40 cubic feet, at the option of the ship. We will assume for our purpose that cargo weighing 1 ton occupies the full 40 cubic feet. As a matter of fact, in this feature is involved a nice point with regard to stowage aboard ship. In nautical parlance, in order

to stow the maximum number of payable tons, the ship should be "full and down." If, for instance, the tonnage space were filled with cotton, the ship would be full but would lack a considerable space of being actually down to her maximum cargo draft. On the other hand, if she were loaded entirely with pig iron she would easily be down to the maximum-load mark without actually being full. However, using 40 cubic feet per ton, and 8,500 tons cargo capacity, the number of cubic feet actually occupied by the cargo on the pier would be 340,000. This might be by mechanical means stacked quite high, but for transit shed purposes such stacking is an added expense. If we assume the maximum speed of transfer, the cargo should be stacked hand high, or, let us say, not to exceed 6 feet, thus requiring 56,667 square feet of stowage space on the first floor. If we consider that a 20-foot aisle space must be maintained down the center of the floor occupied by the cargo of this particular ship, we will have 10,000 additional square feet of floor space required, and if we further assume that a 5-foot aisle must be kept through each cargo door, columns being spaced 20 feet on centers longitudinally, we will require 25 per cent more area than the 56,667 square feet already noted, or a total of 80,834 square feet. Dividing this figure by 500, the length in feet of the ship's berth, gives a width of 162 feet required for export cargo space within the shed.

134. *Railway trackage at waterside.*—While it does not frequently happen that export cargo can be taken directly from the railway cars and placed aboard without previous classification on the pier, we have seen that for such materials as structural steel, steel rails, lumber, etc., such transfer may take place; also, as our pier is approximately 1 mile long, and the shed 162 feet wide, it would plainly be unwise to omit all the railway tracks from the waterside of the shed. Furthermore, it would be quite impracticable to handle a mile of railway cars at one draft. We will therefore assume that we have one standing railway track and one running track, with switches at intervals, and that sufficient clearance is provided for manipulating the cars and for walkways between. Furthermore, in order that wharf tracks may be used with convenience over this outer apron, the tracks will be set flush with the deck.

135. *Hoisting equipment.*—For conveying the sling loads between wharf and ship's hatch we have a choice of portable winches and Burton falls, with the usual cargo mast erected along the face of the transit shed, or electric cranes of the movable type, with rotating or right line booms. The extra cost of cranes over winches and falls will probably at the present time be in the neighborhood of $20,000 per ship's hatch; or with interest at 6 per cent and depreciation, insurance and upkeep at 10 per cent per annum, say $7 per diem. Such a plant as the one under consideration must of necessity be worked intensively in order to justify itself, and no greater part of it should be built than is essential to keep abreast of the business of the port. It should also be worked at least two 8-hour shifts per diem. Under such conditions, and in view of the fact that for the crane we will have an experienced operator who knows his machine, whereas for the Burton fall system we will have two operators, one of them operating a winch with which he is unfamiliar, it would seem that on operation alone there should be no difficulty in saving the difference

in cost, and when the ship's turnaround is taken into consideration, the use of crane equipment would appear to be amply justified. We will therefore assume that a semiportal, rotating jib crane will be provided for each ship's hatch, the right line crane being rejected on account of the restricted area for handling the load at the shed end of the boom. With the two railway tracks, the single track on the deck for the crane, and allowing proper clearance, we will then require 35 feet total width from face of wharf to face of transit shed.

136. *Railway tracks and roadway at rear of shed.*—The normal flow of freight transfer between rail and ship is first from the cars to classification piles on the floor of the shed, thence from classification piles to ship's sling, and the more nearly rectangular the movement with regard to the face of the wharf the greater the efficiency. In unloading the ship the same movement takes place in reverse. Provision is therefore required at the back of the shed for at least one standing and one running track, and as the pier is long there must be a roadway quite equivalent to a city street. Allowing 8 feet for a platform outside the shed, 6 feet from the face of this platform to the center of the first railway track, 13 feet between centers of standing and running tracks, and 6 feet clearance to roadway, adds 33 feet to the width of our pier. If the roadway be taken at a width of 50 feet, 25 feet of this may be considered to belong to the side of the pier on which the ship is berthed. We then have 162 feet actual width of shed, plus 35 feet width of apron between water front and shed, and 58 feet from inner face of shed to center of roadway, or a total of 255 feet. As we have been designing a pier on both sides of which we propose to berth ships, and have only so far developed the accommodations for a ship on one side, the dimensions above given must be doubled; in other words, the total width of the pier is 510 feet. For open construction such a width is beyond all limits of economy, and we have in reality two quay systems back to back.

137. *Railway yards.*—We have in fact used the minimum number of railway tracks for the service of the two sides of the transit shed without taking into consideration the extra trackage required for classification, car storage, etc. Liberal provision must be made both for full and empty cars, and in some instances a great part of this requirement is taken care of on the pier, as notably (fig. 12) Pier No. 8, at Manchester, England. Various factors must be taken into consideration before deciding how many tracks shall be on the pier itself. But it is absolutely necessary either that a large provision of such tracks be on the pier or in a yard not very far distant. We have already referred to the fact that for an important trunk line railway terminating at the New York Harbor the number of cars unloaded per diem was only one-tenth of the actual number of loaded cars on hand, and this, together with a provision for empty cars, must be borne in mind in planning the terminal.

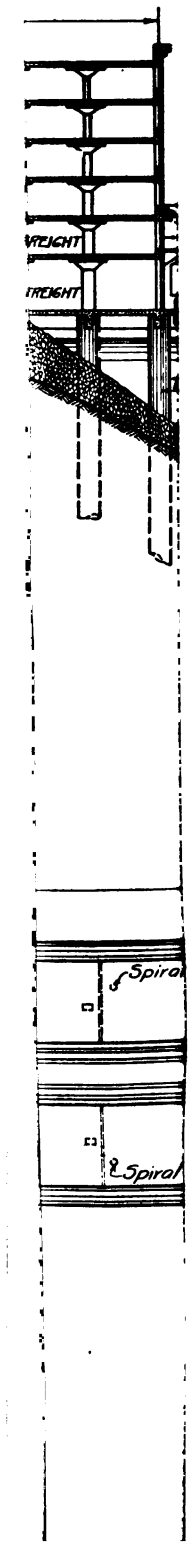
138. *Disposal of dredged material.*—We now know that our general layout plan will consist of alternate slips and piers and that the width of the pier is too great to allow open construction from one docking face to the other. Furthermore, our pier is on shoal water, and slips must be dredged to a depth of 30 feet. There will thus be a large amount of dredged material to be removed. The cheapest

method of performing this where a shore area is available is b means of the suction dredge, and if the area of deposit is not su cient to take all of the material it must be disposed of at sea at considerable added cost. The width of the filled area, therefo bears a direct relationship to the material dredged per foot of wha space, although final economy may require us to dispose of some the material elsewhere. We will therefore consider that the sh area of the main body of the pier will be filled from the dredgin Since this material is largely sand, it will lend itself particularly w to the purpose.

139. *Quay or wharf construction.*—We might retain the fill constructing a gravity wall of concrete, supported by timber pi at the level of the proposed dredging, but such a wall would be s ject to the pressure of the full depth of the retained fill, and wo thus be expensive. We will for our purpose consider that the taining wall is under the outer row of columns for the transit sh and supported by piles cut off at about the permanent wet li This will give a comparatively shallow wall, and allow a natu slope from the dredged depth of 30 feet to the toe of this wall. deck between the face of the pier and the building will be reinfor concrete supported upon concrete piles.

140. *Storehouses.*—We have decided to use the first floor of transit shed for export purposes, and the second story for imp passengers, and customs service. We have also considered that t economy indicates the intensive use of our ground area. Furthe more, we have seen that warehousing is one of the important r quirements of port business, and our American ports are all t prone to the construction of warehouses at a distance from the wate front. We have in this case a promising situation for pile founda tions, and we know in advance that it must frequently happen th import cargo is not taken away promptly, or that too much expo cargo is frequently delivered, and some of it left for the next shi and that there may not be a sailing for the particular port in que tion for some weeks. Delay to succeeding ships will be caused if w do not clear the transit area. Under such circumstances we cou not do better than construct a loft building with floors above th second story for storage. Having made the best possible estimate the business likely to be performed, let us say that we decide to ha four stories for storage purposes only, or six stories in all, and as t commodities will be of great variety and of many marks, also high stacking is usually only required for special commodities, w will adopt a 10-foot story height except for the first floor. As w are designing the most permanent type of construction and desir the very lowest rate of insurance, we will use reinforced concrete throughout. While structural steel columns and main girders with reinforced concrete floors might be cheaper, unprotected structural steel soon yields to a hot fire, and is not nearly so good a fire risk as reinforced concrete. Figure 66 shows in outline the general design of our structure.

141. *Mechanical equipment.*—We have already provided rotating, semiportal revolving cranes for our water front. These should, for ordinary cargo purposes, be from 1½ to 3 tons capacity, and one of them should be provided for each ship's hatch. This does not necessarily require a sufficient number of cranes to accommodate a com-


8 Spiral
8 Spiral

plete line of ships on each face of the pier as such condition will seldom arise and, in case of necessity, the ship's gear can be used. In the ordinary case of quick dispatch the crane and ship's gear should be used together, and, for extraordinarily bulky or heavy packages, a floating crane or floating derrick on the offside of the ship. We will therefore provide cranes of alternating 2 and 5 tons capacity, one crane to each 100 feet of pier, and to work in conjunction with them, storage-battery tractors with trailer cars. The number of tractors and trailers required will, of course, depend upon the tonnage per hatch hour delivered to or taken from the ship. Under present conditions at New York the average performance in this respect is possibly something less than 20 tons per hatch hour, but our effort should be to make the time required to break out the cargo and put it under the sling the limiting factor for unloading, and the time required to stow the cargo, with the maximum economical number of men that can be placed in the hold, the limiting factor for loading. Our crane equipment can probably be depended upon to deliver at least 60 tons per hatch hour, and we will provide tractor-trailer equipment to meet this figure. Taking the average haul at 250 feet, the speed at 125 feet per minute, and the capacity of each trailer at 2 tons, with four trailers per train, we will consider that, including loading and unloading, each trailer train will make 2½ round trips per hour. One tractor will serve two hatches or cranes, and the number of trailers for each hatch will be 12. As additional tractor or trailer units can be supplied at will, the number ordered in the first instance may be reduced below this figure.

142. We will also provide elevators with sufficiently large platforms to transfer a complete tractor-trailer unit between first and upper floors at one lift, and spiral chutes (fig. 52) for the transfer by gravity of all packages of reasonable size between second and first floors.

143. In order to provide the maximum safety against the spread of fire, fire walls will be carried up every 200 feet for the entire width of the building, and an elevator and spiral chute will be provided for each compartment. It may be found in the operation of the terminal that portable belt units and portable stackers can be used with economy on the first floor, but these can be provided at any time. (Figs. 49, 50, 56.)

144. *Justification for transit sheds of large area.*—Such a terminal as indicated by the design just outlined will require a very large initial expenditure, and the usual overhead charges, inclusive of interest on investment, maintenance, depreciation, and insurance, will be correspondingly large. Few private corporations can afford such a first cost, and it is questionable whether the terminal can be made to pay a commensurate net return. Undoubtedly its operation must be intensive to produce such a result. At the same time the indirect returns to the community are large. Those in authority at Liverpool have been quoted as saying that they can load and unload ships very rapidly, but that the transit shed becomes blocked with cargo, and is therefore the bottle neck in the shipping operation. The transit shed is the reservoir and its contents must be kept moving to produce the best results. Our transit shed provides but 324 square feet of floor

area per lineal foot of wharf; whereas the transit shed at Manchester (fig. 12), No. 9 Dock, provides 430 square feet, and the proposed new quay warehouse 646 square feet.

145. The illustrations show other piers and quays of great width, notably, figures 18 and 19, Portland docks; figure 20, Seattle dock; figure 24, Halifax pier, and figure 27, Commonwealth Pier at Boston. Other terminals offering wide area for the storage of cargo in transit are also illustrated herein. At Marseilles (fig. 67) there is a pier 420 feet wide, with 3-story transit sheds. This port was a pioneer in constructing sheds of more than one story as, three-quarters of a century ago, it designed the Traverse de la Joliette, with wide 2-story sheds. At this port new modern cranes are continually being added to keep abreast of the constantly increasing commerce. Figure 68 shows a single-story transit shed 365 feet wide under construction at Le Havre, France. Figure 68A shows other wide construction at Le Havre. Figures 69, 70, and 71 indicate something of the quays of the port of Antwerp, Belgium, with regard to cranes for handling miscellaneous cargo. Figures 72, 73, 74, and 75 illustrate the opinion of the United States with regard to requirements for the rapid turn around of vessels during the Great War. These show the army bases at Boston, Brooklyn, N. Y., Philadelphia, and New Orleans. Note that while all of the storage space for the Boston installation is not directly on the water front, it is at least just behind the transit sheds and connected thereto by bridges.

146. As a final justification for ample transit shed area and the best mechanical equipment, we have (1) the fact that any error in excess gives at least valuable storage space, and (2) the enormous expense of holding a first-class cargo ship in port longer than necessary. The United States Shipping Board is at this writing holding its tonnage at a price of $160 to $180 per dead-weight ton, and new tonnage can probably not be had for less than the smaller figure. Using the latter figure, we have for our 10,000-ton ship a first cost of $1,600,000. The annual interest upon this sum at 6 per cent is $96,000. Taking repairs and maintenance at 5 per cent, $80,000; depreciation at 3½ per cent, $53,000; insurance, 4.2 per cent, $67,000; we have a total annual expense of $296,000. From an investigation of the operation of vessels of similar size, it is believed that the fuel used per annum in port for a ship plying between, say, New York and Liverpool, will amount to $33,000; the port compensation for officers and crew, $27,000; meals in port, $5,000; stores in port, $2,000, or a total annual expense of $363,000, or in round figures, $1,000 per diem. The daily charge for dockage or side wharfage will be at least $350; the daily cost of stevedoring on the basis of 20 men per gang, about $650, or a total minimum actual cost in port per diem of $2,000. To attract investment to so hazardous a business as the operation of ships, the normal daily profit should be at least 20 per cent of the investment, or, roughly, another $1,000 per diem. So that we may say in general that the minimum cost of holding a first class 10,000 dead-weight ton cargo carrier in port per day is about $3,000. In practice it is, of course, quite out of the question to keep each ship's berth occupied for anything like the entire time, but the above figures are sufficiently illuminating to show something of the possibilities of saving by means of ample dispatch facilities. The present tendency

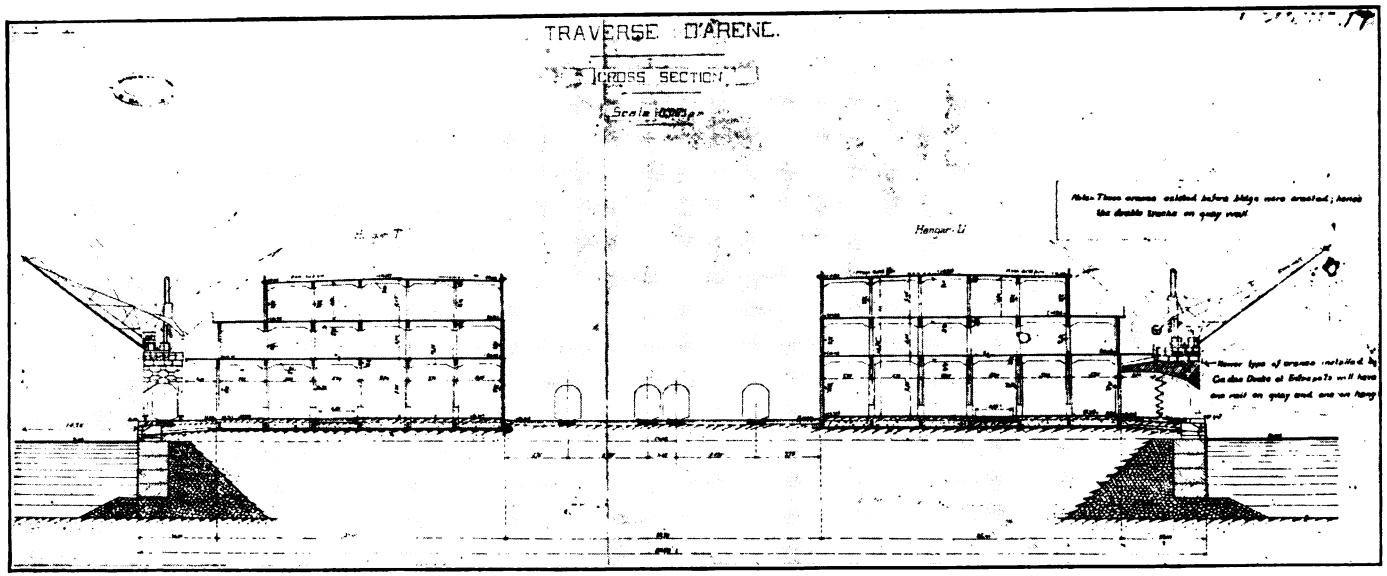


FIGURE 67

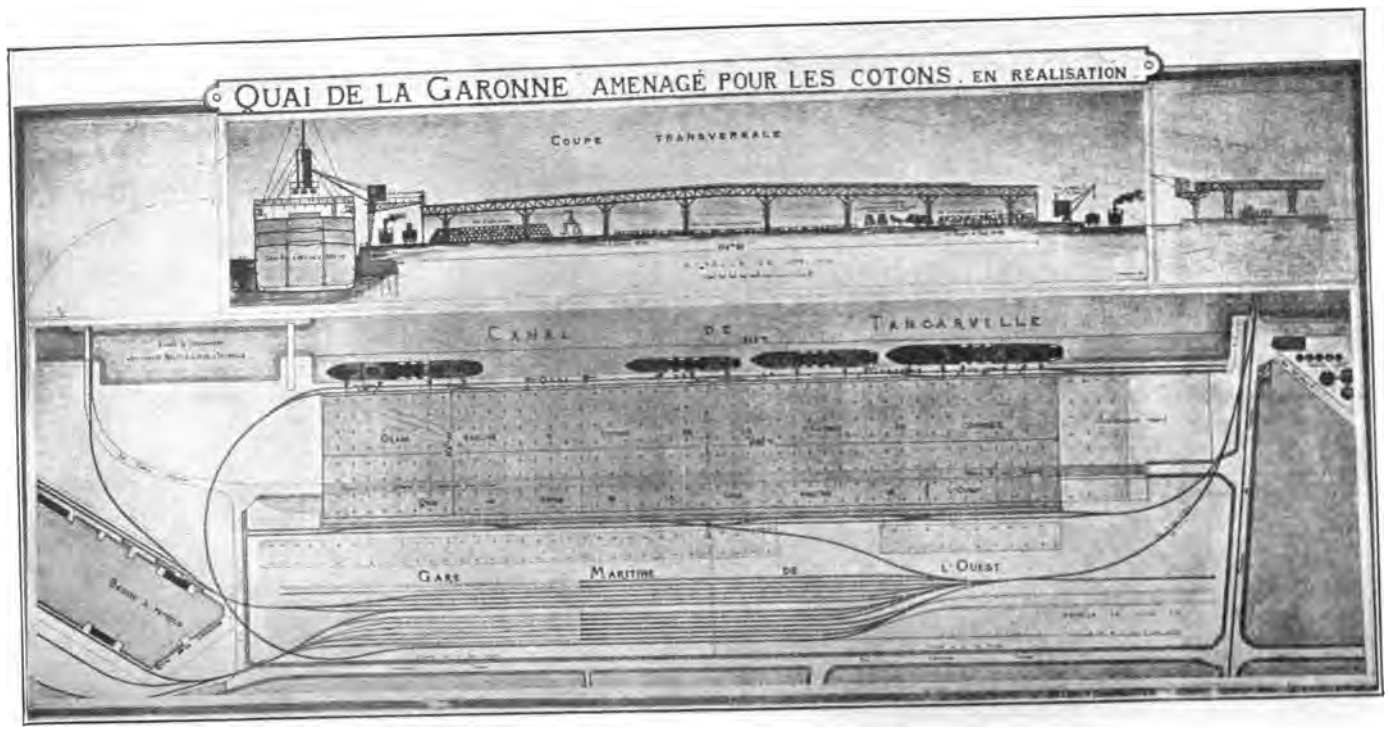

QUAI DE LA GARONNE AMENAGÉ POUR LES COTONS. EN RÉALISATION
COUPE TRANSVERSALE
CANAL DE TANCARVILLE
GARE MARITIME DE L'OUEST

FIGURE 68

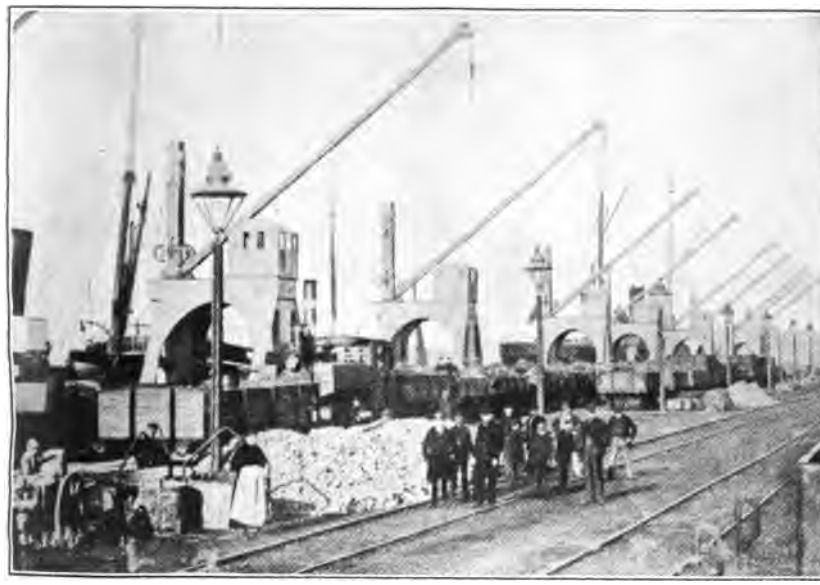


FIGURE 69

FIGURE 70

FIGURE 71

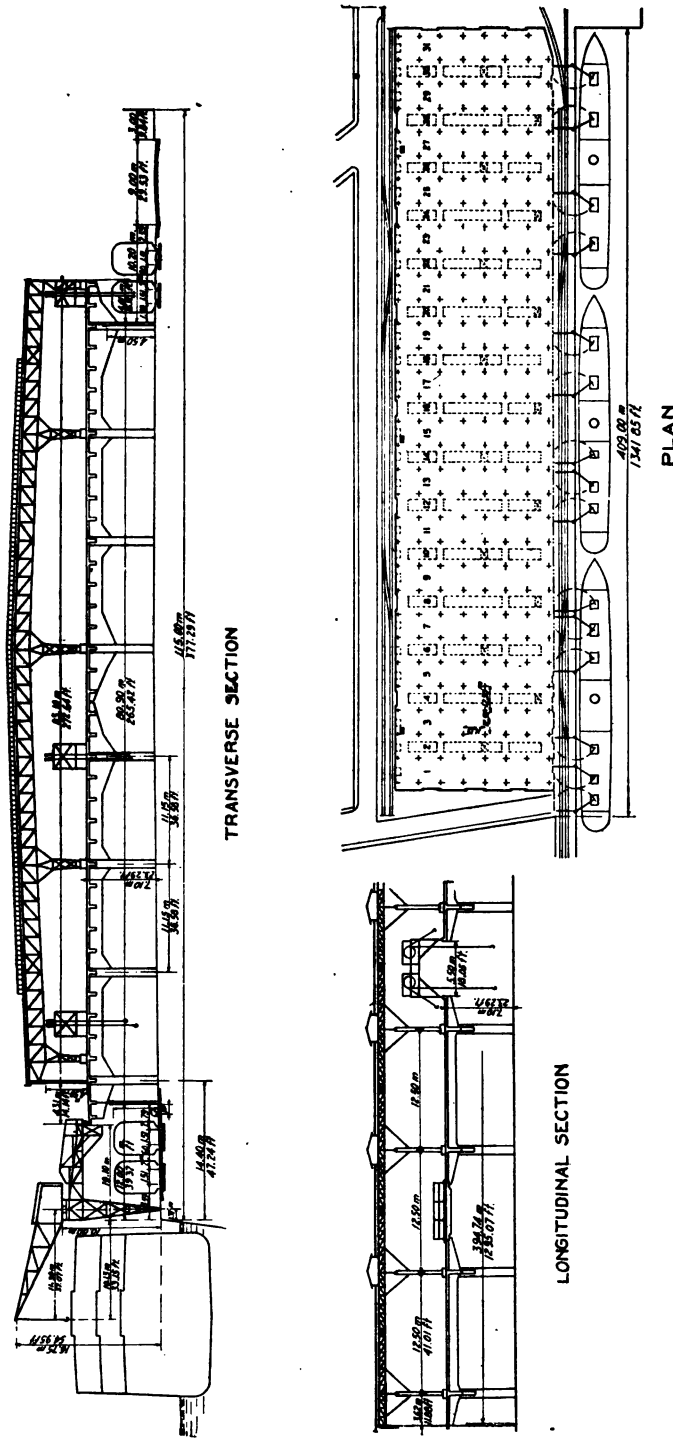


Figure 68A.

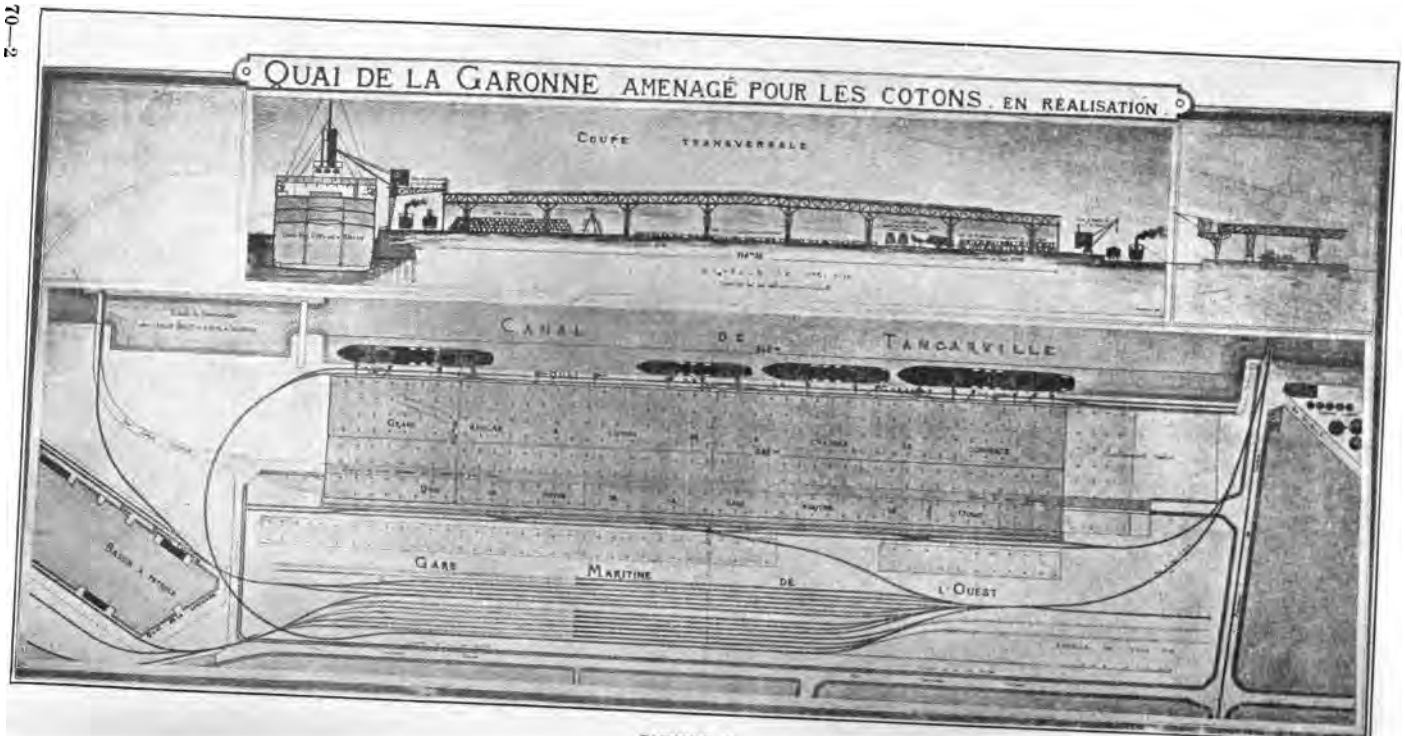

QUAI DE LA GARONNE AMENAGÉ POUR LES COTONS. EN RÉALISATION.
COUPE TRANSVERSALE
CANAL DE TANCARVILLE
GARE MARITIME DE L'OUEST
BASSIN A FLOTS

FIGURE 68

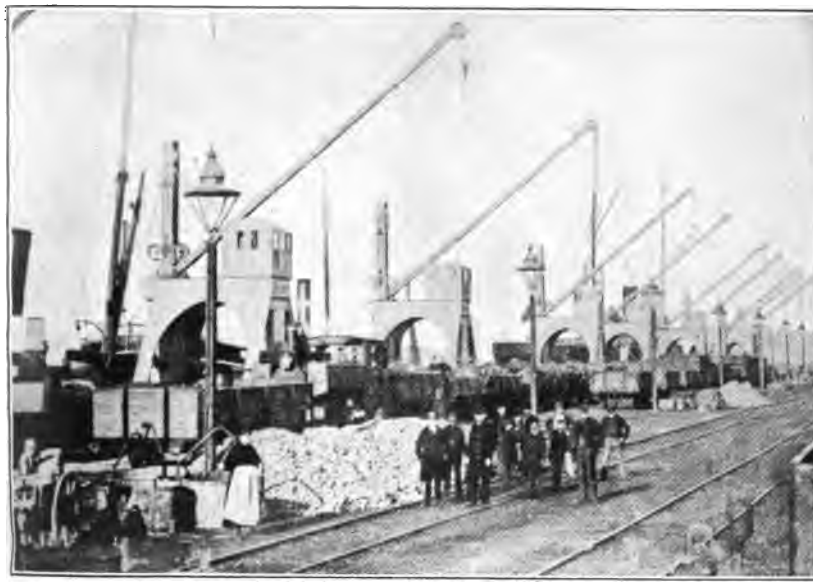
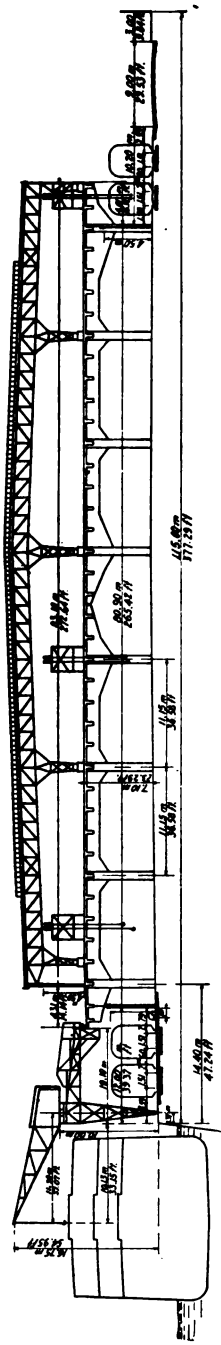


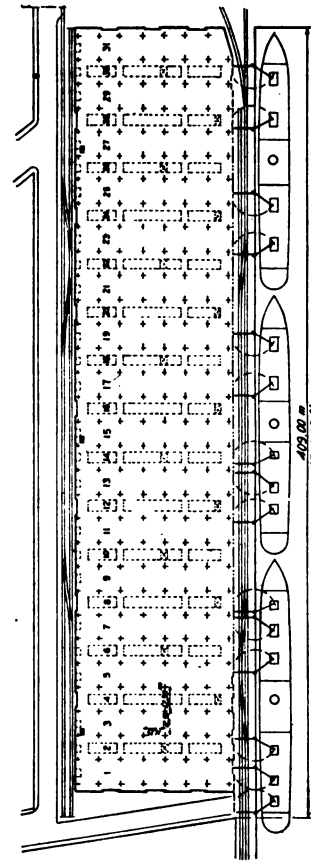
FIGURE 69

FIGURE 70

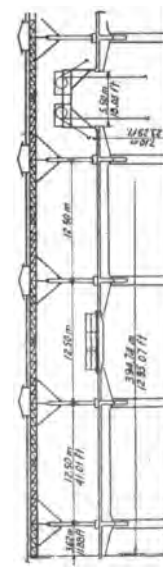
FIGURE 71



TRANSVERSE SECTION

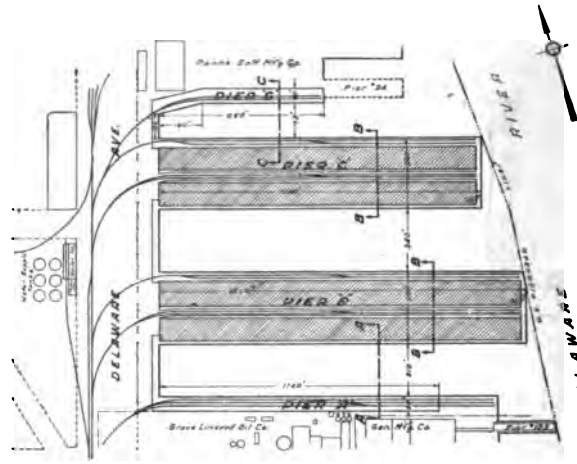


PLAN

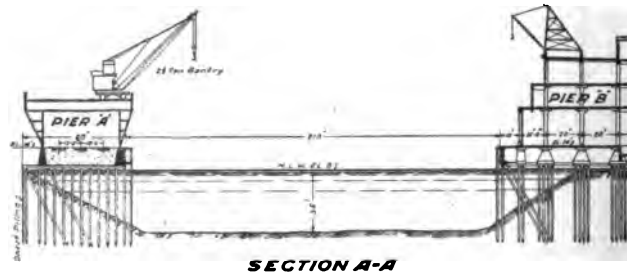


LONGITUDINAL SECTION

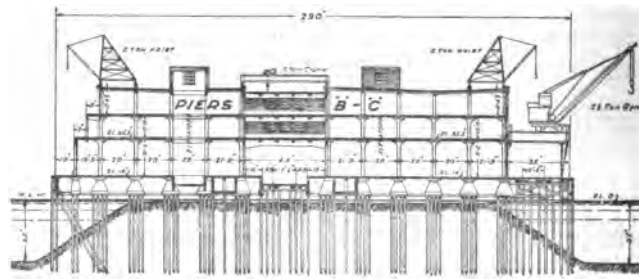
Figure 68A.



PLAN

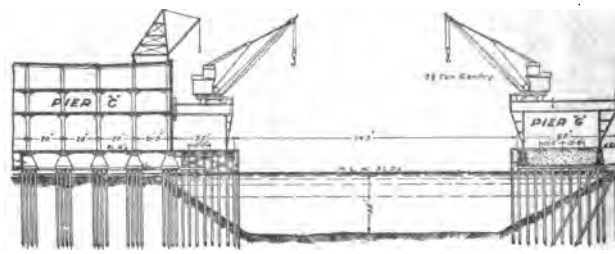


SECTION A-A



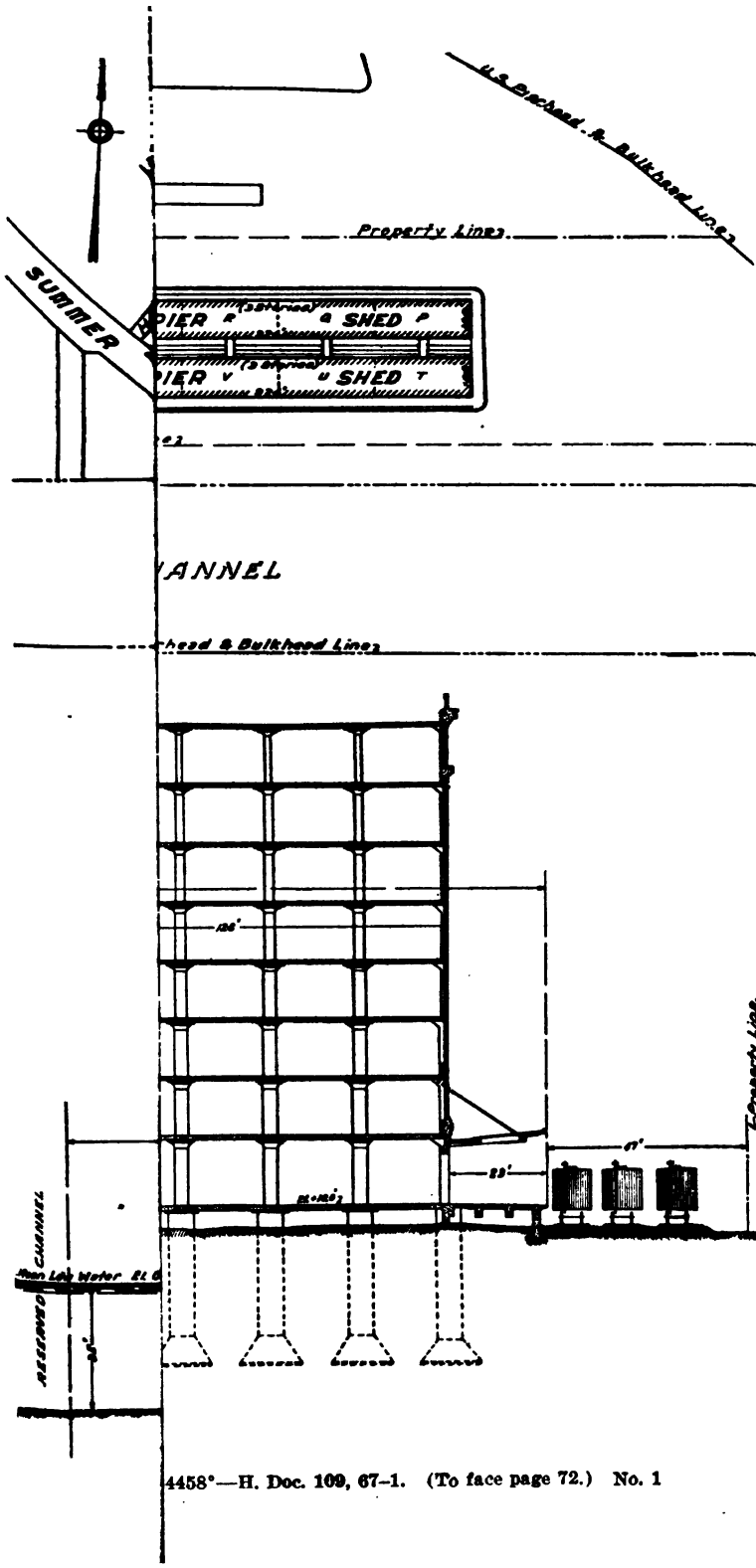
SECTION B-B

SCALE IN FEET



SECTION C-C

Figure 74.



4458°—H. Doc. 109, 67–1. (To face page 72.) No. 1

in terminal construction is undoubtedly in the direction of larger transit shed accommodation and more mechanical equipment. Already considerable progress has been made, and as the situation becomes more fully understood we may expect to see more progress. Edwin J. Clapp, in his book on the Port of Hamburg, states:

> The entire port is operated on a financial plan less calculated to make it a profitable investment than to bring prosperity to the city. As compared with other great European ports, Hamburg's dues are not high; in respect of that vital need, dispatch, none stands higher.

147. If we would compete with foreign nations in the ocean carriage of our exports and imports, it is along such lines that we must plan. Profitable interest upon the investment is worth our effort, but the welfare of the city, the State, and the country constitute the real goal. The terminal is, after all, just one important link in the whole commercial chain.

148. *Port terminal charges.*—The preceding paragraph suggests that something should be said upon this subject, which in itself is so broad and so differently treated in both our home ports and those of the principal maritime nations abroad as to be worthy of special study. Such a study is now being made by at least two associations of port authorities in this country, and the matter is also being investigated by the Board of Engineers for Rivers and Harbors. We can only touch here upon the general principles involved. Further light is thrown upon the subject by another quotation from Clapp's The Port of Hamburg, which is as follows:

> It is Hamburg's advantage that it is a State as well as a city; that it has no limit of bonded indebtedness imposed by a superior power; that it is not obliged to make any specific return on money invested in the harbors and channels. Hamburg proceeds on the principle that tax on traffic is bad. The mere fact that a shipment is made via Hamburg is no evidence that its owner is able to pay a tax sufficiently high to make a full return for all facilities afforded him. When the unhindered flow of commerce has crystallized into wealth in the hands of merchants, forwarders, warehouses, and shipowners, it is time to tax this wealth primarily through a property and income tax.

149. A further pertinent quotation from the same source is taken from the statement of the Prussian minister of public works in answer to a complaint from the port of Stettin, in which the minister spoke, in part, as follows:

> It is not allowable to compare Stettin with Hamburg and Lübeck. The latter are purely commercial states which can devote their entire interest to fostering their commerce. The Prussian State has far wider interests and obligations. We can not exert our entire influence in behalf of a single commercial port.

150. At the same time it is well to bear in mind that our port terminals must be made nearly or quite self-supporting. The progressive ports of San Francisco and New Orleans do very well in this respect, and there is no reason why other ports should not be equally successful.

151. In general it may be said that port charges are assessed (1) against the ship and (2) against the cargo. In all cases there will be separate charges for pilotage and towage, and in some instances for harbor dues. The two former of these should be compensatory for the class of service involved, and nothing further need be said concerning them. We are in this treatise particularly concerned with the revenues for the terminal itself. At New York practically

the only charge at the terminal is for dockage or side wharfage, usually assessed upon the length of the vessel. More generally at other ports there is a charge for dockage or side wharfage based upon the registered tonnage of the vessel, and other charges based upon commodity tonnage and area occupied, and frequently differing for practically all the various commodities handled over the floor area of the transit shed. Perhaps the best general rule is that a tonnage charge should be made against the vessel for occupying its berth, and another charge against the cargo for passing over or remaining in the transit shed, and in order that an adequate flow of commerce may be set up and maintained, definite limitations should be placed upon the time the cargo may remain upon the floor of the shed under the first charge, with penalty rates for demurrage or overtime storage. Custom in this respect in our home ports is far too varied; the terms used are differently applied in different ports, and definition and uniformity of practice are crying needs.

PORT TERMINAL CONTROL.

152. One of the greatest obstacles to the progress of our shipping business and to the promotion of our export and import traffic is the lack of unity of management. In this respect we should take a leaf from the book of our British competitors, who have made this subject a study for many years of successful maritime business. Every considerable British port has a really unified management.

153. *Forms of port control.*—In general it may be said that port terminal control is of three kinds—(1) public, (2) railroad, and (3) private.

(1) *Public control.*—This is best illustrated by the practice of such ports as Hamburg, which is a commercial state, and of London, Liverpool, and Bristol, England, which more nearly represent what we should endeavor to attain in the United States. The port of London suffered for many years from the internal competition of a number of separate dock companies within the port. It was not until July, 1908, that the entire port property was taken over and put under the London port authority, competition within the port thus eliminated, and the port as a whole put in position to direct its energies to competition with other ports. This port authority is called in England a "trust," not in the sense that this word is generally used in this country but in the sense of a corporation operating without profit for the public benefit. This does not mean that port charges are not assessed, but only that the revenues obtained from such charges are devoted exclusively to the interest of the port terminal, and not, as in the city of New York, to such extraneous matters as the cleaning of the city streets and other items of city maintenance.

In other words, where New York devotes a considerable part of its revenue from the city-owned piers to general city purposes, London devotes its tolls to that part of the welfare of the community which is bound up in the promotion of its shipping trade. Another organization called "The Trinity House" is responsible for the lighting and buoying of the river. The metropolitan police are the port's guardians, and the corporation of the city of London supervises the sanitary conditions with regard to shipping. The port

authority is empowered to collect tolls on ships and goods, and has full jurisdiction over the various docks and terminals. The port authority is constituted as follows:

Appointed members, 10—1 by the Admiralty, 2 by the Board of Trade, 2 by the London County Council (being members of the council), 2 by the London County Council (not being members of the council), 1 by the city corporation (being a member of the corporation), 1 by the city corporation (not being a member of the corporation), 1 by the Trinity House.

Elected members, 18—17 by the payers of dues, wharfingers, and owners of river craft, 1 by the wharfingers.

In addition, the chairman and vice chairman may be appointed from outside the membership of the authority, making the total possible number 30.

The organization at Liverpool is known as the Mersey Dock and Harbor Board. It is quite similar in its constitution to the London authority, and has 28 members, 24 of whom are elected by the dock rate payers, i. e., persons paying rates and dues on ships and goods only—the remaining 4 being appointed by the Mersey Conservancy Commission, which consists of the first lord of the Admiralty, the chancellor of the Duchy of Lancaster, and the president of the Board of Trade. The Board of Trade, unlike our boards of trade in the United States, is a national institution, corresponding in many respects with our Department of Commerce. The effort is made, in making appointments to the Mersey board, to give the various trading interests in the local shipping community a proportionate representation, and this at the present time is said to work well. Such organizations as those at London and Liverpool may seem to the casual reader unwieldy, but each organization is divided into separate working committees with apparently good effect. The port of Bristol is owned and operated by the municipal corporation, which thus has jurisdiction over the entire dock system, the control being vested in the city council, which for purposes of administration appoints a subcommittee. This committee employs the executive officials and gives them a free hand in the management. It is declared that politics plays no part in this administration.

(2) *Railroad control.*—Some of the ports of England, as notably that of Immingham, are entirely in the hands of the railways. The port terminal is operated as a part of the railway system, and as a means of getting business. Many ports in the United States are in fact operated upon this same railway basis, the port terminal charges being nothing, or nominal, wherever the railway is enabled to get business by offering dockage to the ship.

(3) *Private control.*—Terminals of this description are operated by private individuals or corporations in the pursuit of their own business in all parts of the world. They may be adapted to the handling of only one product, or to miscellaneous freight. The manufacturing concern may be located at the terminal, and may use its water front facilities in direct connection with its business only, or in some instances may conduct a separate terminal and warehousing business.

154. *General.*—In general it may be said that no port taken as a whole in the United States comes under any one of the three above-

named headings. In all ports of any size we have all three methods of administration. It is true that at San Francisco and New Orleans there are public port authorities, controlled by the State, but at San Francisco the harbor board confines its activities to the water front at San Francisco, while the railways have terminals across the bay at Oakland, on which side of the harbor there are also private terminals. At New Orleans also the State board and the railways have separate terminals.

155. *Railway port terminal charges.*—The National Government supervises railway rates through its Interstate Commerce Commission. These rail rates are very complex, and on individual commodities bear little relation to the actual cost of the service performed. Many low grade commodities are carried at rates below actual cost, while on others of high grade an excessive rate with regard to service performed may be charged. The whole subject of rail rates is too complex to be dwelt upon here, but suffice it to say that under the present system the railroads in general use their water terminals to buy business. The terminal rates charged, as heretofore stated, are nominal, or at most insufficient to pay the fixed charges upon terminal investment. The loss is made up in the rate for the line haul. Under such circumstances there are few of our port terminals where the private individual or corporation can show a sufficient profit to attract capital to progressive construction, and it is difficult to demonstrate to city or State authorities that public funds should be expended to the extent needed for quick dispatch.

156. *Public management.*—Every United States port should own its water front, and this should be controlled by a port authority composed of business men who have an intelligent grasp of the export and import business, and who are willing to devote sufficient time to the subject. These should be appointed without regard to political affiliations, and should take the broad view that the port is the property of the people at large, and that the provision of the best facilities will promote quicker ship dispatch, attract more ships, and thus enlarge the commerce of the port; that while the port terminal should be self-supporting, the charges should be adjusted to produce this result without injury to business, and that the growth of the port will mean the growth of the city, and increased material prosperity to the individuals of the city and State. Those States which have only one main port should in particular exert themselves to develop it along the best modern lines, and the first step in this direction is the appointment of a competent port authority.

INLAND WATERWAY TERMINALS.

157. The principles of design of water terminals for the Great Lakes are not materially different from those of the ocean terminals. The main difference lies in the fact that the range of water level for the Great Lakes is almost negligible, and that the draft of Lake ships is limited to 20 feet. However, as the improvement of the St. Lawrence River for the accommodation of deep draft ocean-going ships is in contemplation, it is doubtful whether a progressive community would be justified in planning its terminal for less than a final depth of water alongside of 25 to 30 feet—this especially in view of the

fact that in most instances the additional cost of carrying the foundations 5 to 10 feet lower will be but a small percentage of the total cost. We have already described certain bulk coal and ore terminals for the Great Lakes as applicable to ocean terminal practice, and it seems unnecessary to go further into this subject. Up to the present time all but a small percentage of the traffic of the Great Lakes has been in bulk materials. The vessels engaged in carrying package freight are comparatively few, and much smaller than the coal, ore, and grain carriers. These package freighters in most instances have side ports, and the problem of transfer between ship and terminal is one of trucking.

158. *Canals and rivers.*—Inland waterway traffic, exclusive of that of the Great Lakes, is conducted on canals and rivers. There was a time before the advent of the steam railway, and extending for a period into the steam railway era, when most of the canal and river traffic was from town to town along the banks of the waterways. In those times there were few improved roads, and the first civilization took place along the waterways as practically the only means of communication. Packet boats, usually of shallow draft, were constructed to carry both freight and passengers, and the terminals were very simple. The advent of the railways changed all this, and communication between cities and towns became much more rapid by rail than by water, even where both communities were on the same stream. To-day the terminal which does not have direct communication between rail and water is in general comparatively unimportant. It is the transfer between rail and water that we have to consider here.

159. *Navigable depths and variation of water level.*—Most of our inland waterways have a very restricted navigable depth. They may be divided for our purpose into those which have practically constant depth, and those which by reason of the difference in flow between the dry season and the flood season have wide variation of depth. On the one hand, artificial canals, constructed usually between locks, have practically a constant depth and level, while such rivers as the Ohio and the Mississippi have a variation of as much as 60 feet between low water stage and extreme high water. Canal depths vary from that of the Erie Canal in New York State, with a depth of 12 feet, to the older canal systems with as little as 4 feet. The upper Mississippi has a least navigable depth of 5 feet, and between St. Louis and New Orleans a least depth of about 8 feet.

160. *Terminals for waterways of constant level.*—For waterways of approximately constant level, or, let us say, within the same limits of level as ocean terminals in the United States, namely, about 15 feet, the inland waterway terminal does not differ materially from that of the ocean terminal, except in size. The same principles in general govern. We have the transfer between rail and river barge to take the place of the transfer between rail and ocean carrier. Whereas the ship has a great molded depth, and may, particularly when light, tower high above the wharf, the river craft draws little water even when loaded, and its molded depth is small, so that the difference in level between its main deck and the deck of the wharf varies between narrow limits, and the total difference is never great. As in the case of the ocean terminal we adopted the 10,000-ton deadweight ship as a measure, we can perhaps in the case of the inland

waterways not do better than use the covered barge designed for the United States Government Mississippi-Warrior River experimental service. This barge has a length of 230 feet, a beam of 37 feet, and a molded depth of 12 feet, with a deep-load draft of 10 feet. Its capacity is about 2,000 tons. If we consider that for clearance purposes the berth for this barge will be 240 feet long, and if we use the figure of 40 cubic feet per ton, a height of pile of 6 feet, and 25 per cent aisle space, we will arrive at 70 feet as the width of our covered terminal, and this should prove a fair maximum where provision is made for unloading several barges at the terminal at one time. If, on the other hand, it is only proposed to unload one barge at a time, the terminal may be made narrower and correspondingly longer to attain the same floor area. The same reasoning will, of course, apply as to the open space required for bulk material.

161. *Terminal for handling bulk cargo.*—The same principles apply to the handling of bulk material on inland waterways as have been touched upon already for ocean terminals. In general it may be said that the transfer between rail and barge is usually made by direct dump from trestle to barge, or by endless belt or endless-chain bucket conveyor. The transfer between barge and rail will usually be made by clam-shell bucket, or belt bucket digger operated from a crane or similar machine, and either dumped direct into railroad cars or transferred by belt or chain conveyor. Under present conditions by far the greatest part of the cargo carried on inland waterways is in bulk, the obvious reason for this being that bulk transfer can be made at a much lower figure than can that of package freight. Figure 76 shows in diagrammatic form two terminals designed to handle coal between the coal mines in southern Illinois and Clinton, Iowa. The lower diagram shows a trestle running at 5 per cent grade to the proper elevation for the dumping of hopper-bottom cars, in order that the coal may be deposited in barges alongside the wall by means of chutes. The cross section shows the general arrangement and relationship between coal car and barge. It will be noted that at this point the variation in level of the water is 50 feet, adding enormously to the expense of the construction. The upper diagram shows the reclaiming plant at Clinton, the mechanical equipment indicated being similar to that employed on the Great Lakes for coal and ore. The clam-shell buckets are designed to take 10 tons of coal at one operation and transfer it either into railroad cars or back into the coal pit, from which a reclaiming bridge can again transfer it to a storage pile of larger area. This bridge is also capable of rehandling the coal from the storage pile into a hopper contained in its pier leg, from which it can be discharged to railroad cars at the rear of the storage area.

162. This terminal was also designed to handle package freight, and for this purpose it was proposed to extend the wall and to build a freight shed 40 feet wide by 200 feet long, equipped with semiportal, right-line gantry cranes, as shown in the same figures to the right. The right-line crane when ready for operation extends within the shed and is thus enabled to transfer sling loads direct from the barge to the floor of the shed or from shed to barge.

163. Figure 77 shows a simple arrangement for an inland waterway terminal where there is small variation in water level. Here the

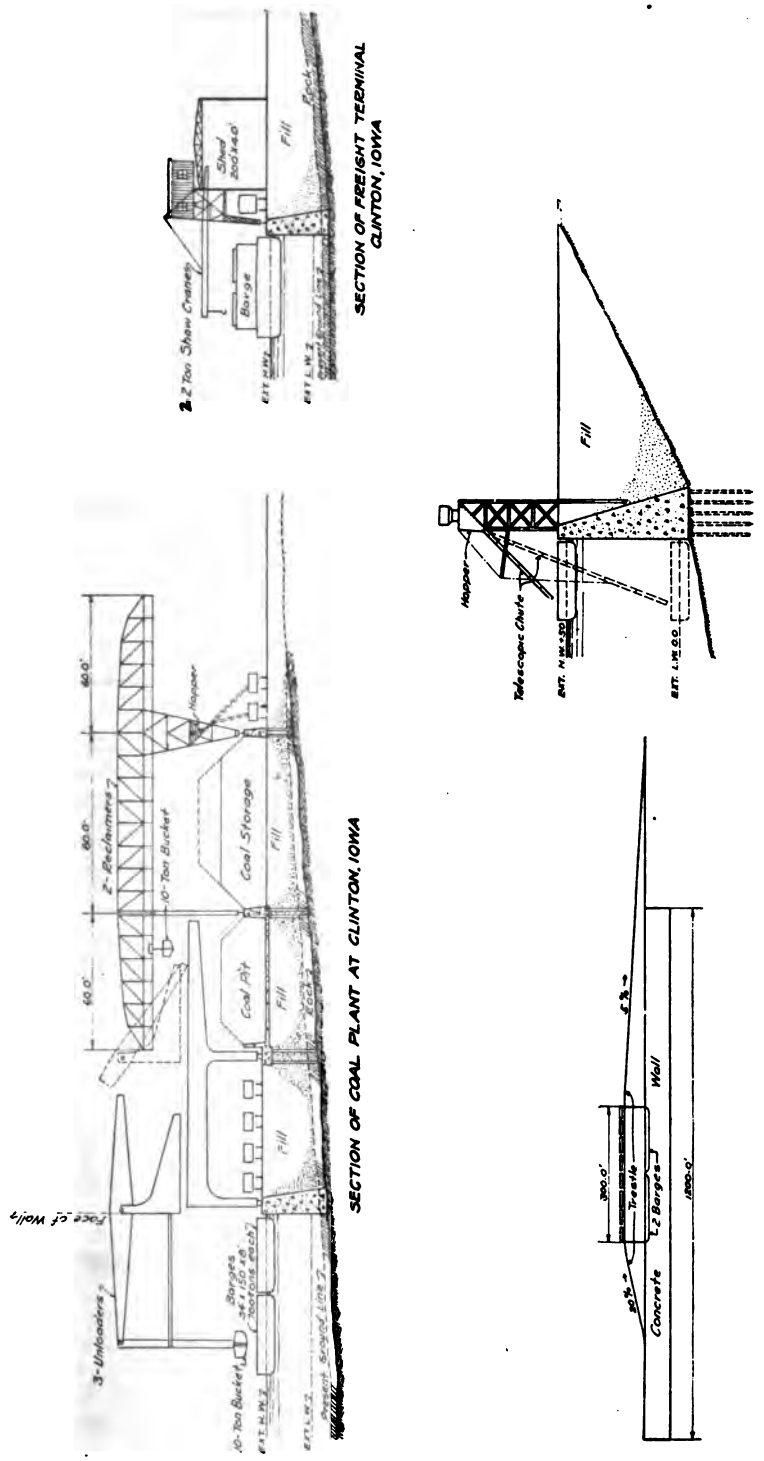
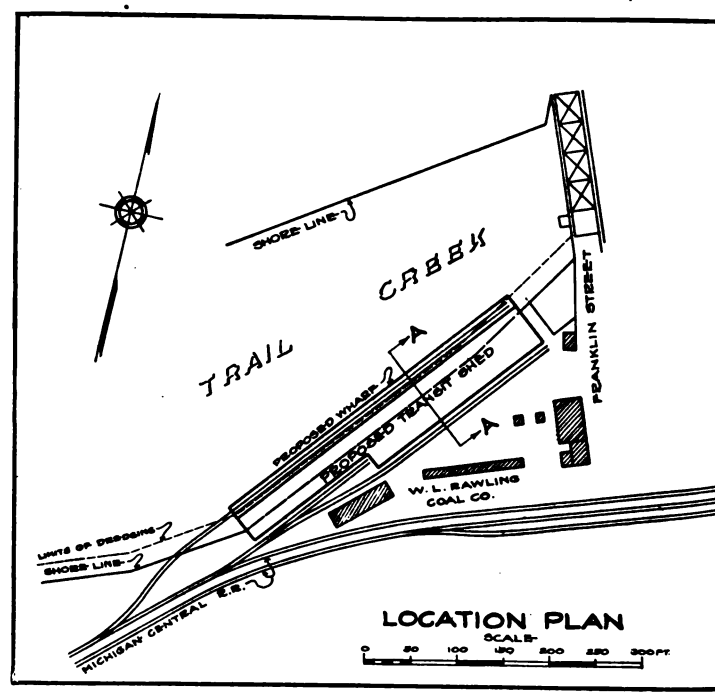
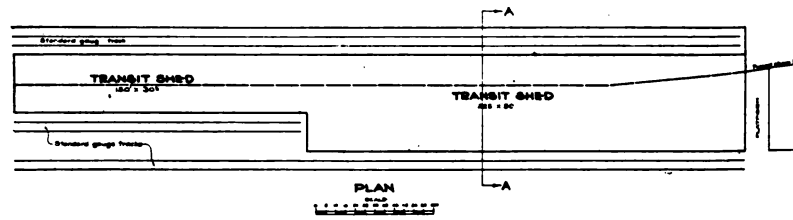

2-2 Ton Shaw Cranes
Shed 20x40'
Barge
Fill
Rock
EST. H.W.
EST. L.W.
SECTION OF FREIGHT TERMINAL
CLINTON, IOWA
Hopper
Telescopic Chute
EST. H.W. +20
EST. L.W. 0.0.
Fill
FRONT VIEW & SECTION OF LOADING PLANT
BIG MUDDY RIVER
Face of Wall
3-Unloaders
Barges 34'x150'x8' 700 tons each
10-Ton Bucket
EST. H.W.
EST. L.W.
Present Scraped Line
60.0'
2-Reclaimers
10-Ton Bucket
Coal Storage
Coal Pit
Fill
Rock
SECTION OF COAL PLANT AT CLINTON, IOWA
Wall
Trestle
2 Barges
Concrete
300.0'
1800.0'

Figure 76.


SHORE LINE
TRAIL CREEK
FRANKLIN STREET
A
PROPOSED WHARF
PROPOSED TRANSIT SHED
W. L. RAWLING COAL CO.
LIMITS OF DREDGING
SHORE LINE
MICHIGAN CENTRAL R.R.
LOCATION PLAN
SCALE-
0 50 100 150 200 250 300 FT.


A
TRANSIT SHED
TRANSIT SHED
A
PLAN

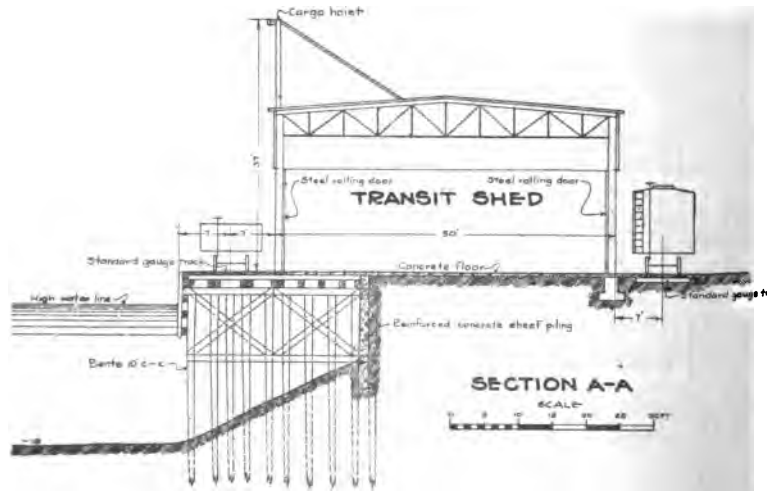

Cargo hoist
Steel rolling door
Steel rolling door
TRANSIT SHED
50'
Standard gauge track
Concrete floor
Standard gauge track
High water line
Reinforced concrete sheet piling
Bents 10' c-c
SECTION A-A
SCALE-

Figure 77.

cargo mast is provided for a Burton fall, and tracks for railroad cars are placed both on the water front and behind the transit shed.

164. Figure 78 shows a similar arrangement for a terminal designed for the Rock Island district of the Mississippi River. Here the mechanical equipment consists of a standard-gauge railroad track crane of the kind carried in stock by many companies. If this terminal were for the use of ocean-going ships, the crane would necessarily have to be elevated upon a tower or similar arrangement, but in this case the standard crane is quite satisfactory. Note that for the inland terminal, as for that for ocean use, it is quite necessary to have ample railroad connection and trackage.

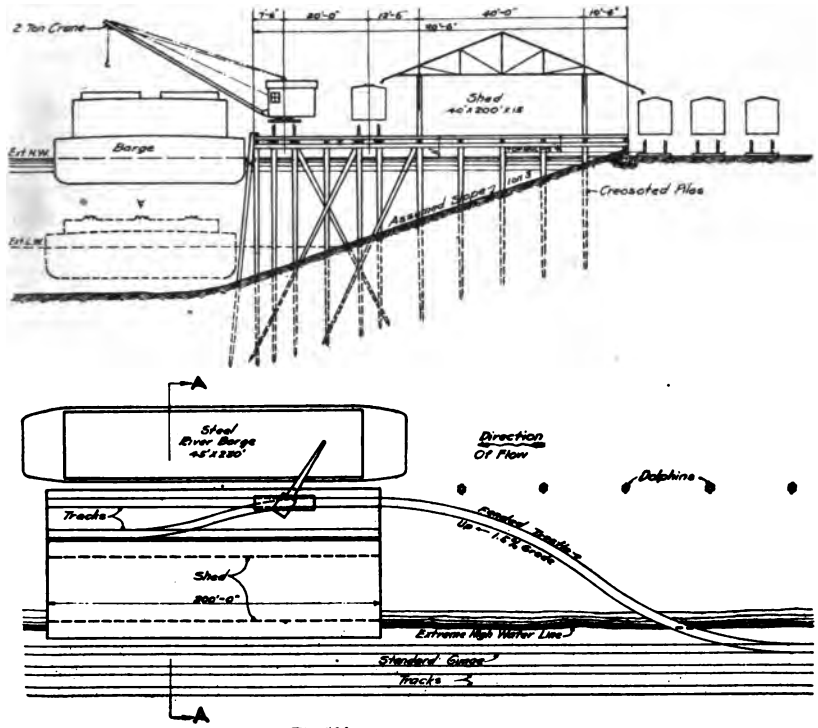


Figure 78.

165. *Terminals for rivers of wide variation of water level.*—Where the water level varies widely at different seasons of the year, it is often a difficult matter to design the terminal in such a manner as to provide economic handling within reasonable limits of first cost. Figures 79 to 90 offer some suggestions along these lines.

166. Figure 79 shows a paved levee of practically uniform slope. The design is for handling bulk material by derrick boat, portable hopper, and balanced-drive cable system. The levee slope is continued by means of an open-work trestle for the purpose of securing sufficient height for dumping. A balanced cable system, operated by means of the hoisting engine, hauls one car up the slope as the other goes down. A clamshell bucket on the floating derrick trans-

fers the bulk material from barge to portable hopper which in turn discharges into the dump cars. This is for the transfer of material from water to rail only.

167. Figure 80 shows the same principle applied to package freight. In this case the movement may be either in or out.

168. Figure 81 shows a combination of cable car and portable belt conveyor units for transfer of package freight in either direction.

169. Figure 82 shows transfer between river boat and car by means of portable conveyor units. When the water is low a considerable number of units is necessary, and as the river rises a lesser number may be used. This scheme has the disadvantage that it does not provide for packages of unusual bulk or weight, the capacity of such portable units seldom running above 800 pounds, and usually being limited to about 400 pounds. The amount of material that can be handled where the packages are within the weight and size limits is, however, very large.

170. Figure 83 shows a combination of derrick boat, portable hopper, and portable conveyor units for bulk material, such as coal or grain, direct from barge to car.

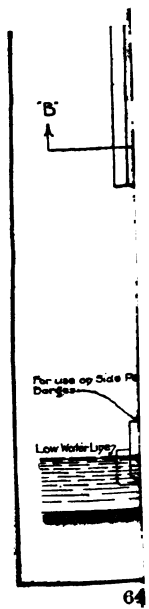
171. Figure 84 shows a monorail tractor-trailer unit working over the movable loop system of trackage. The tractor carries two units, each with two hooks, so that four sling loads can be handled in and out at one operation. The parallel rails of the bridge are spanned by a movable, self-propelled bridge, having switch points projecting down upon the parallel tracks, and thus making a complete loop over which the tractor-trailer unit travels.

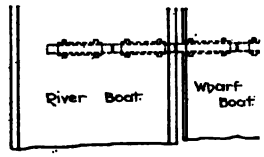
172. Figure 85 shows the same arrangement of overhead bridge in combination with a tractor-trailer train system on the level of the shed floor.

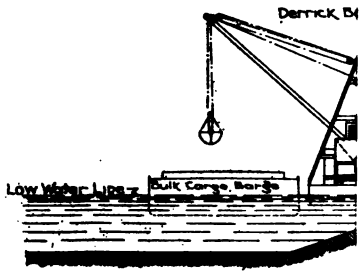
173. Figure 86 shows a combination of revolving cranes with continuous cable loop system. The upper level contains a loop system for the handling of bulk material and dumping it into railroad cars. The loop system working on the incline between the lower and upper level is for package freight. Such a cable-loop system works usually at a speed of 180 feet per minute, and the cars can be coupled and uncoupled from the continuously moving cable as desired.

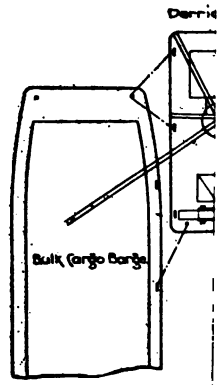
174. Figure 87 shows the design for a terminal on the Lower Mississippi River, which is intended for both bulk and package freight. Here the derricks are fixed to the corners of the sheds on the wharf boat and on the upper level, and the hoppers are movable. The cars are drawn up and down the levee and trestle by means of a hoisting engine, detached at both the upper and lower levels, and pushed by hand to the point desired; or for bulk materials the entire car may be picked up by the derrick and dumped. In the middle of the plan is shown an arrangement of portable belt units for operation at this same plant.

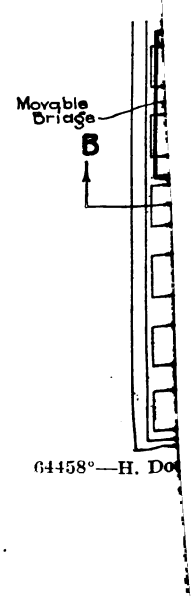
175. Figure 88 shows a continuous chain belt haul for handling 2-ton trucks between wharf boat and freight shed. The chain belt is contained in a tunnel below the surface of the paved slope of the levee. The trucks are pushed upon the chain belt, automatically engaged by a hook, transferred, and automatically released. As the water rises in the river, sections of the chain belt are removed in order to shorten the haul and keep the apparatus above the water line.

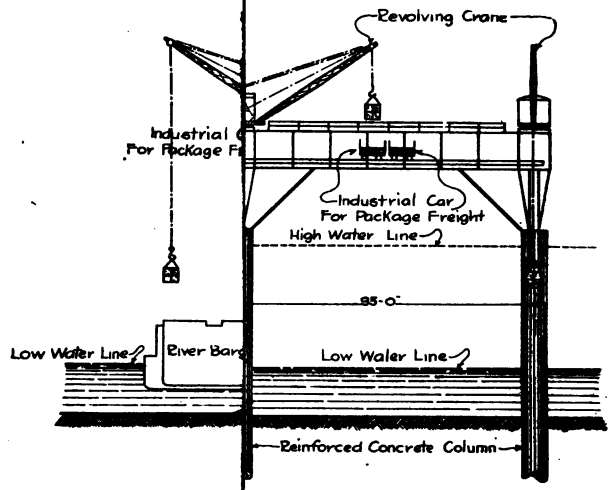

"B"
Low Water Line


River Boat
Wharf Boat

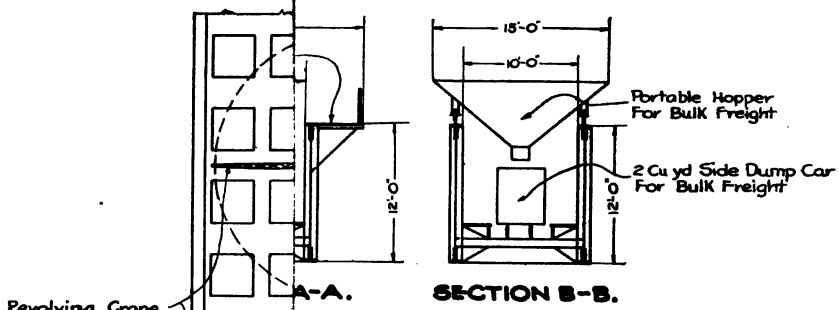

Derrick Bo
Low Water Line
Bulk Cargo Barge


Derrick
Bulk Cargo Barge


Movable
Bridge
B

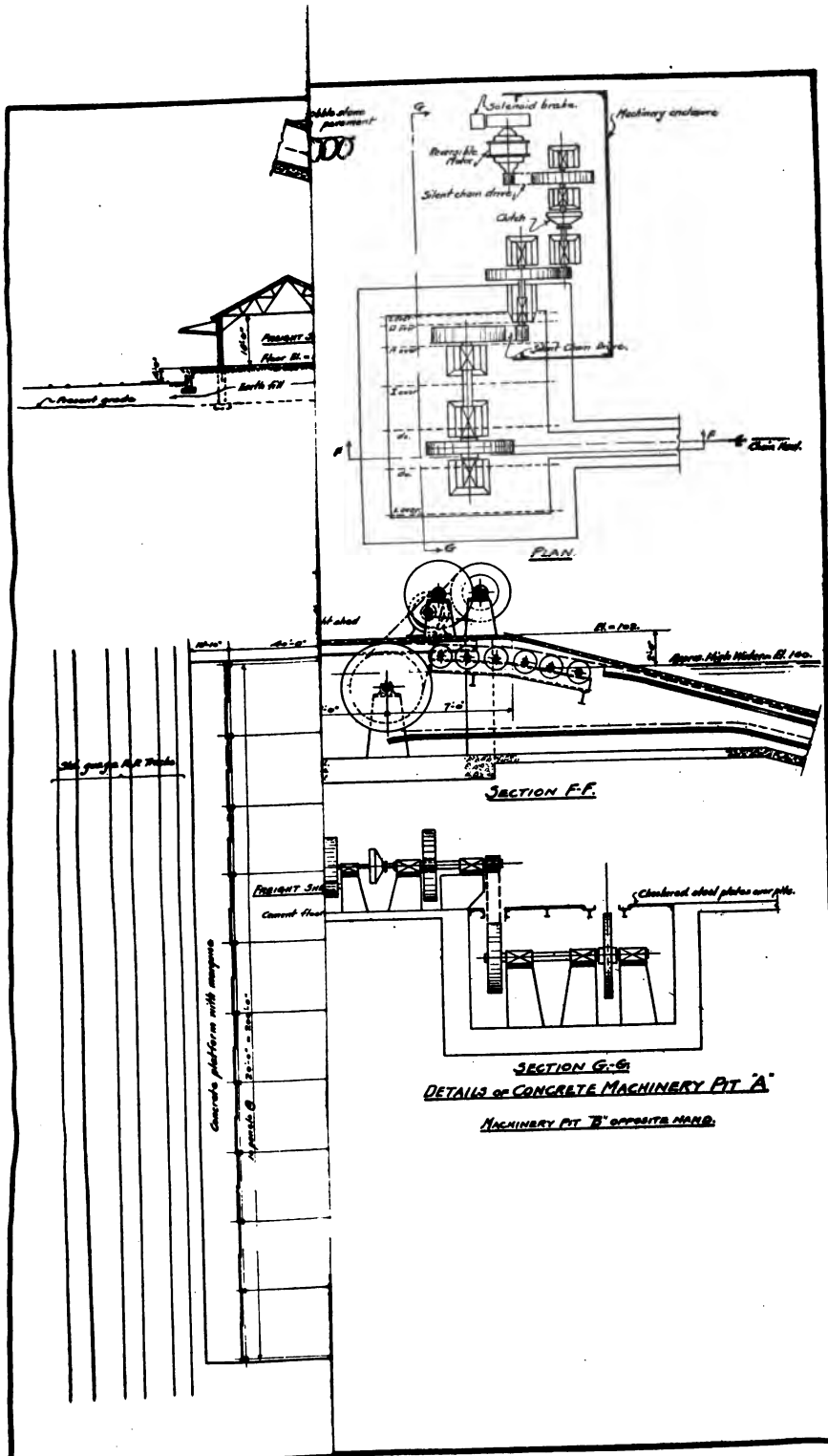


FRONT ELEVATION



A-A.

SECTION B-B.



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176. Figure 89 shows a somewhat similar scheme for a terminal for Memphis, Tenn. Here the chain belt is operated on a hinged bridge which moves up and down in guides supported by an outer wharf. As the water rises the bridge is raised to accommodate the

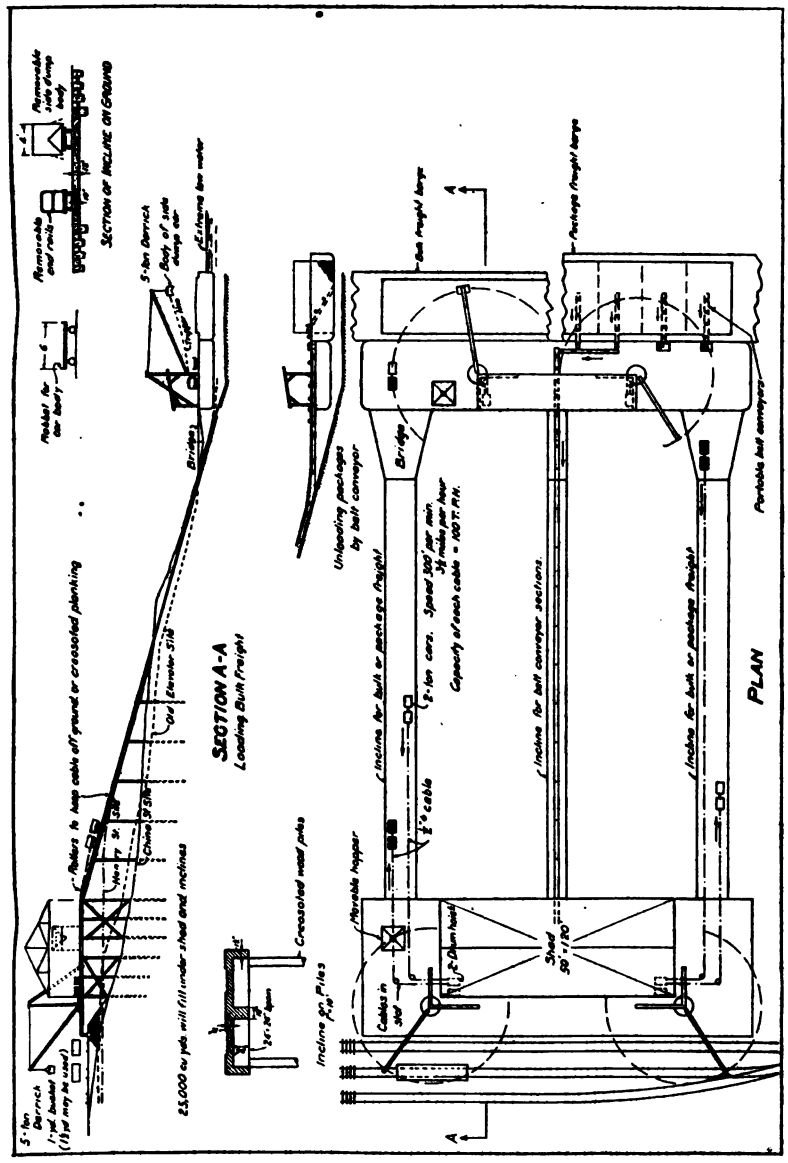


Figure 87.

belt to the deck of the wharf boat. This chain belt furnishes an excellent means of transferring trucks between shed and wharf boat, but fails to provide for such materials as timber, steel rails, structural steel frames, etc. To handle these, a trestle provides trackage

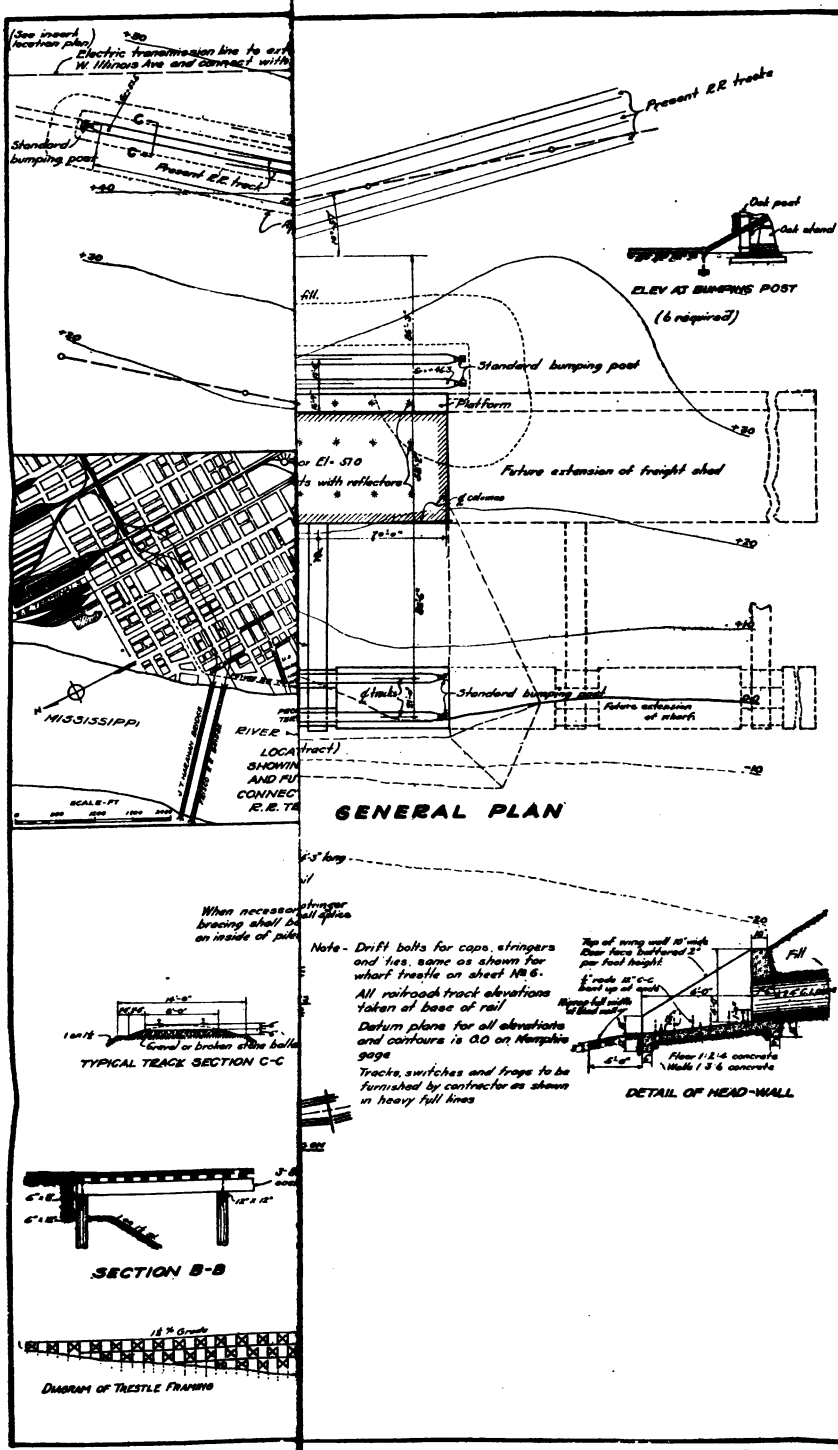
for cars from shore to outer wharf. A standard-gauge crane handles material direct from car to barge or wharf boat. For such material the wharf boat would be removed, and the barge moored alongside the wharf. A small bridge provides trackage across the gap occupied at times of high water by the hinged bridge and chain-belt conveyor. This small bridge is lifted by means of the crane.

177. Figure 90 shows another tentative layout for a river terminal at Memphis, Tenn., based upon the principle of the car-float transfer for railroad cars. Standard-gauge tracks at a slight angle with the water front run down the levee at a uniform grade and support a movable platform or cradle, which in turn has railroad tracks of standard gauge corresponding with those below. The whole cradle is moved up and down the fixed track on rollers to correspond with the level of the water at any particular time. The railroad cars are run over this cradle and upon the tracks of the car float. The float in this case is especially rigged with transfer apparatus consisting of a right line gantry crane and sections of belt conveyor. The difficulty with this form of transfer is that there is no room for classification of cargo between river barge and car float. Furthermore, considerable time of the working gang would be lost each day while awaiting new set-ups. The difficulty about classification might be overcome by interposing a covered barge to take the place of the transfer shed ashore, but even in that event the equipment would be somewhat unwieldy, with the further disadvantage that a considerable extent of water front would be blocked for other terminal use.

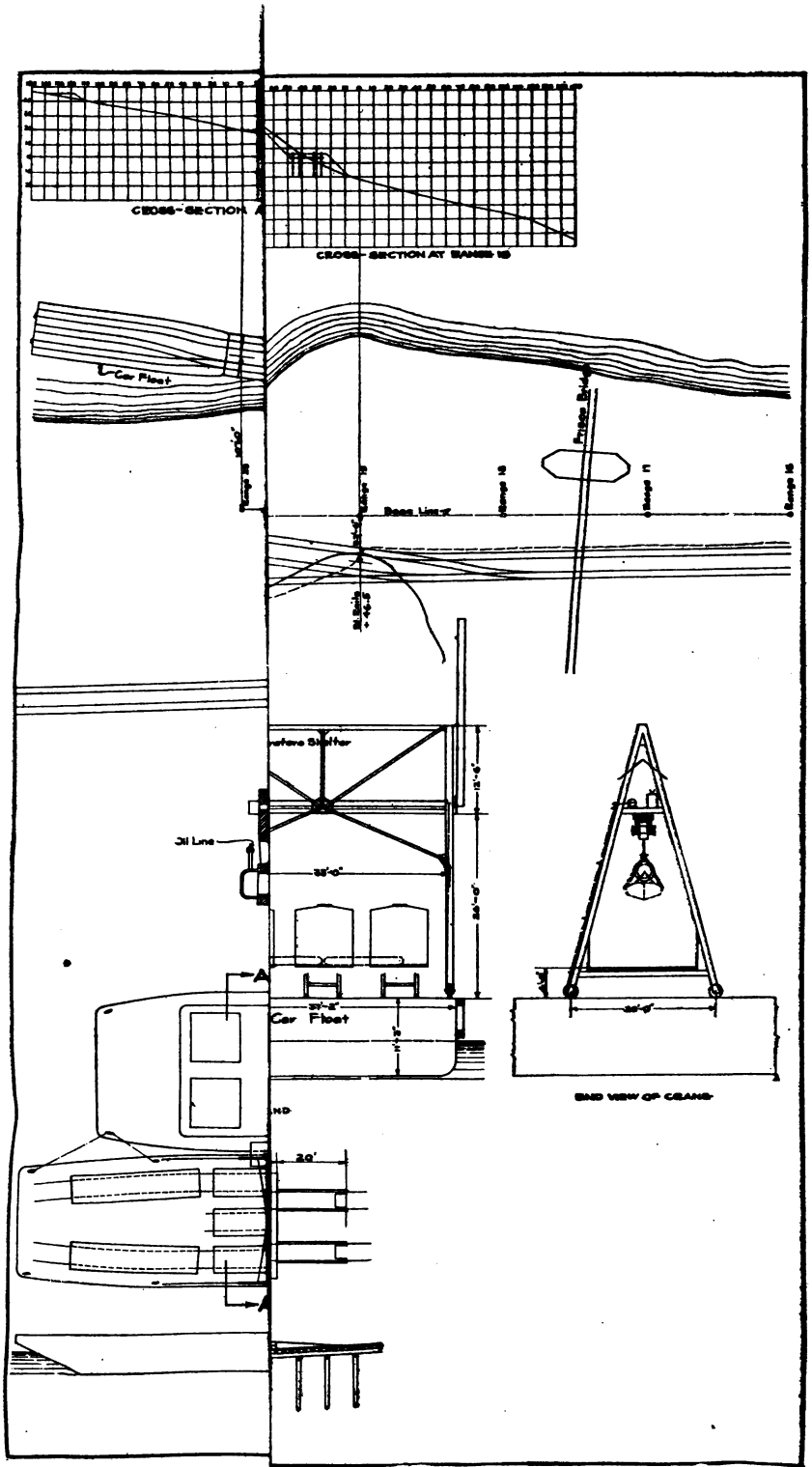
178. As in the case of ocean terminal planning, each individual terminal site presents its own problem requiring especial expert treatment.

CONCLUSION.

179. We have endeavored to describe typical existing terminals, and to outline the method of making general plans for terminals of appropriate type and construction for the harbors and waterways of the United States suitable for various commercial purposes, and adapted to the varying conditions of tides, floods, and other physical characteristics. A full treatment of the subject would require a work of several volumes. Under the circumstances it has been necessary to omit detailed discussions and to mention only the principal mechanical appliances. Many special devices are in use for handling bulk and cargo commodities, a large number of which are only suitable for packages of fairly uniform size. The problem of handling miscellaneous freight is complicated by the many sizes, kinds, and weights of packages required. The fact remains that there are already in existence, and performing efficiently, many devices which are adaptable to terminal transfer purposes. These devices are illustrated in the trade catalogues of the manufacturers, and every terminal engineer should have in his office a complete file of this trade literature. The American Association of Port Authorities has appointed a special committee to investigate and report on handling facilities at port terminals, and as part of its work an index of mechanical equipment is being compiled. This will doubtless be available to those interested in the subject.


Present E.E. tracks
Oak post
Oak shoe
ELEV AT BUMPING POST
(6 required)
Standard bumping post
Platform
Future extension of freight shed
Standard bumping post
Future extension of wharf
GENERAL PLAN
Note - Drift bolts for caps, stringers and ties, same as shown for wharf trestle on sheet No 6.
All railroad track elevations taken at base of rail
Datum plane for all elevations and contours is C.O. on Memphis gage
Tracks, switches and frogs to be furnished by contractor as shown in heavy full lines
TYPICAL TRACK SECTION C-C
DETAIL OF HEAD-WALL
SECTION B-B
DIAGRAM OF TRESTLE FRAMING

—H. Doc. 109, 67–1. (To face page 84.) No. 1



—H. Doc. 109, 67–1. (To face page 84.) No. 2

180. In certain automobile works, the men engaged in building the vehicles scarcely move all day long, the various parts being conveyed to them mechanically, and men being employed only where machines can not do the work. While we can not hope to attain such efficiency at our terminals, we can at least bear in mind that the time required to break out cargo from the hold of the vessel and put it under the hatch for import, and the time required to stow this same cargo for safe shipment in the hold for export, should be the limiting feature in terminal efficiency, and that all operations leading to or from the hatch should be so managed that at no time between car and ship is speed impeded. This, as we have already seen, requires that railroad tracks and the ship's berth be arranged for the shortest and most direct movement between the two methods of conveyance, and as cargo is of many marks, and of many sizes and shapes of packages, large classification area is required. Every day spent by the ship in port over and above that actually required entails a loss of from $2,000 to $5,000 per diem, in addition to the loss caused by the undue holding of freight cars, the deterioration of perishable freight, etc. Every extra dollar spent in transportation must eventually be paid by the consumer, and a considerable excess cost may handicap or even prevent our merchants from engaging in export and import business. If our merchant marine is to succeed against the handicaps of larger crews, greater personnel compensation, and better and more expensive food, we must carefully visé every detail of transportation cost, inclusive of ship operation. We may gain a temporary advantage by the substitution of fuel oil for coal under ships' boilers, or of Diesel engines for steam drive, but our competitors will quickly follow with these improvements.

We have proven on the Great Lakes that we can handle ore and grain for 5 cents a ton where it used to cost 50, all by the application of mechanical appliances. While, as before stated, the package freight problem is much more complex, it can be solved by proper management, combined with one or several handling machines. While the principal European ports have their water fronts equipped with many excellent cranes where we have mostly ship's gear and portable winches, almost the entire handling of goods between crane and car abroad is by hand truck, and it is doubtful whether foreign labor is as adaptable to the management of mechanical devices as is our own. In this direction, therefore, there is undoubtedly room for a vast improvement in terminal handling methods.

181. Commissioner Woolley, of the Interstate Commerce Commission, in an address before the Virginia Bankers' Association in 1919 made the statement that "terminal facilities on our inland waterways are just as primitive as they were when Mark Twain was learning to be a pilot on the Mississippi." He further stated in the same address:

> In an investigation incident to the 5 per cent case a few years ago, the Interstate Commerce Commission, through one of its ablest examiners, went into the subject of terminal cost at four cities. At New York it was found that the expense of handling a car from the time it landed within the terminal limits of Jersey City until it was delivered to its destination in Brooklyn or Manhattan, including lighterage, was approximately $35. At Chicago, where there is no lighterage, it was found that the cost of handling the same car within the terminal limits was $10.35. At Binghamton, N. Y., a city of be-

tween 50,000 and 60,000 population, the cost was $1.80. And at Salamanca, N. Y., which has a population of between 5,000 and 8,000, and is a railroad division point, the terminal cost was $3.80. Similar investigations were made at 14 points, large and small, at another time in the State of Texas, and the variance as to cost was just as great and just as confusing.

San Francisco has municipally controlled terminals, and a flat charge of $2.50 per car for handling all cars within the terminal limits is made. New Orleans has a publicly owned belt, and makes a low uniform terminal charge. At New York, the terminal sore spot of the Nation, the utter injustice of taking care of $35 per car in the line-haul rate, in other words, of making the innocent consumer over much of our land stand a tax that New York may continue to grow and monopolize the export and import business of the country, is impressing many of the big-minded citizens of our metropolis.

The figures above named, while doubtless correct at the time, must be much greater now, but the general principle still holds.

182. In a recent address, Mr. Spencer Smith, vice chairman of the New York, New Jersey Port and Harbor Development Commission, is quoted as stating that statistics gathered by a prominent man in New York show that the present inadequate facilities in the metropolitan district have put a burden on the district of $200,000 a *day*, or $73,000,000 a year.

183. The New York, New Jersey Port and Harbor Development Commission has recently expended approximately $500,000 in an investigation of conditions at the port of New York, devoting much attention to the collection and analysis of terminal costs. They are quoted as follows:

On the basis of 1918 prices, it is estimated that the terminal costs were about $2.25 per ton at Manhattan stations, $2.08 at Brooklyn, Harlem, and Bronx stations, and $3.01 freight lightered.

184. Under the heading of "Saving in ship's turnaround possible," the following quotation is taken from the report of this same commission:

Evidently this simultaneous working of ship's gear and cranes would effect a saving in ship's time, but without improved layout and provision of ample transit floor space the benefits of cranes would not fully materialize. With such provisions, together with adequate regulation to insure deliveries of goods to and removal from the pier at the proper times, it seems conservative to say that the present average time of discharging and reloading can be cut in two.

Twenty days is about the average time required under present conditions at the port of New York for ships of the capacity of these four for the two operations of discharging and loading. Less than one-fifth of the total time the ship is at the pier is actually used in working the hatches. Support for this statement is found in the performance record of nine ships and in the actual ship clockings.

Evidently there are reasons for the waste of ship's time in the harbor other than the lack of machinery. The rehandling of freight on account of lack of transit floor space for incoming cargo, insufficiency of space to assemble outgoing cargo, and the untimely arrival of outgoing cargo stand prominent among these reasons, and cause relatively greater delay than could be made up by any crane installation.

The foregoing estimated saving of ten days for each turnaround is the basis for the approximate figures presented on page 380, which indicate that when the charter value per day of the individual vessel and the number of vessels that dock at a wharf in a year are taken into account the saving in ships' days justifies ample floor space and a considerable expenditure for machinery.

185. Mr. J. J. Mantell, of the Erie Railroad, a recognized expert in transportation matters, recently made the statement that it costs